

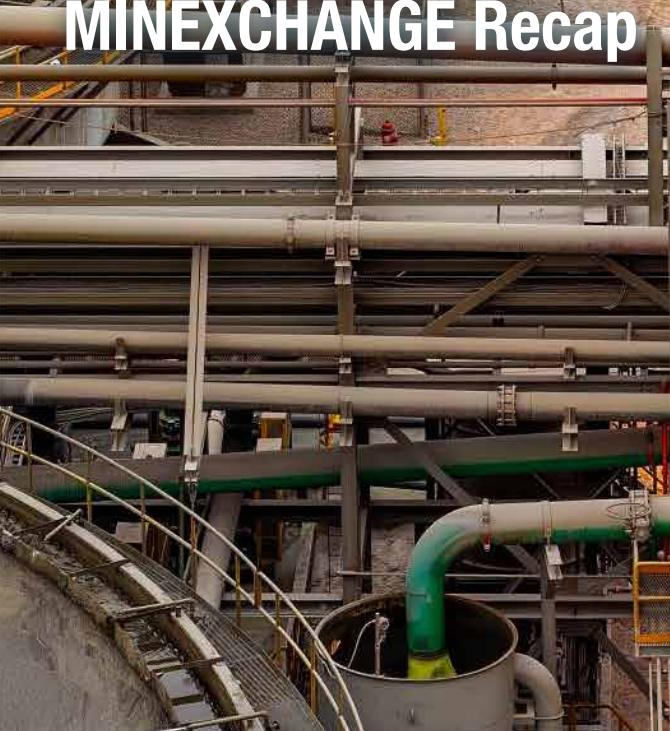
April 2025
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Mining engineering

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Understanding precipitation accumulation patterns is critically important to ensure proper infrastructure design, water management planning and risk management, and reliably inform decision-making for mine management. On page 16 Homin Kim and Brant Whiting present a case study on forecasting precipitation. On page 24, *Mining Engineering* editors provide a recap of the MINEXCHANGE 2025 SME Annual Conference & Expo. Cover photo credit: Shutterstock. Cover design by Ted Robertson.



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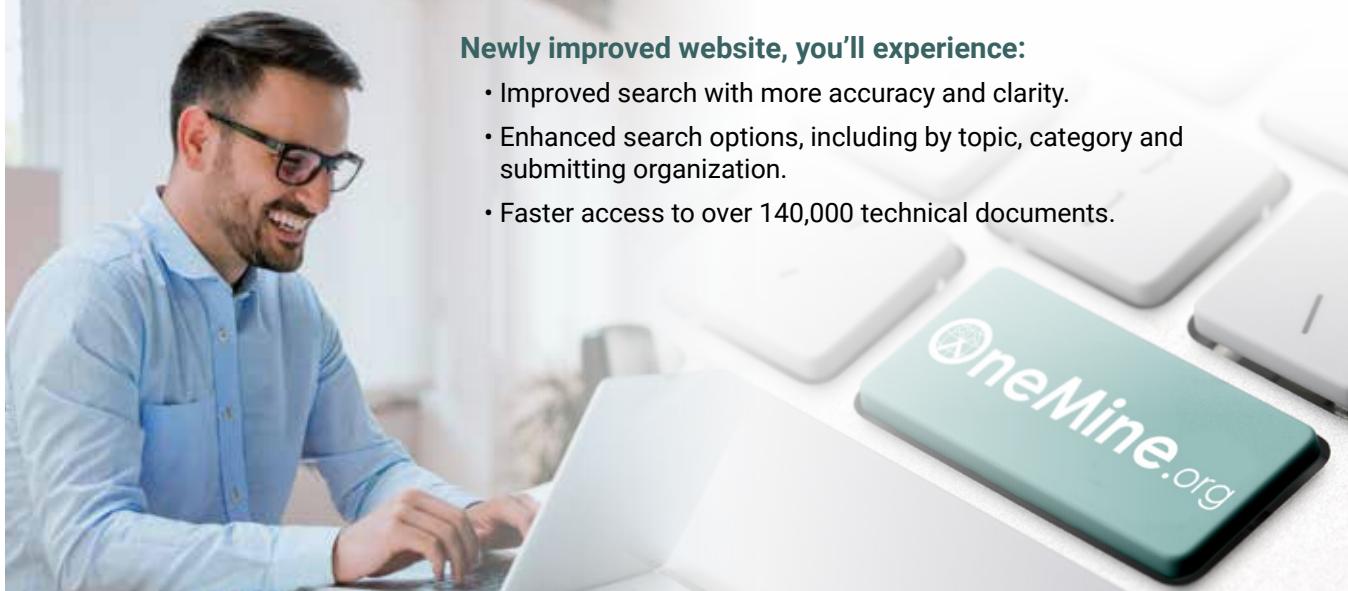


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President's Page

Looking ahead to a year of change; SME will face challenges and opportunities



**Bill A. Hancock
2025 SME President**

I am honored to serve as the 2025 SME President and look forward to all the work that lies ahead. Particularly, I am looking forward to interacting with our members, SME leaders and stakeholders to maximize SME's value whether that is by improving existing programs performance or developing new programs.

Over my 50 years as an SME member (I am joining the SME Legion of Honor this year) in the mining industry, I have met many people. I am looking forward to being reacquainted with old friends and making new friends in the coming year.

Our job number one this year is recruiting a new executive director (ED). In 2024, Dave Kanagy announced his March 17, 2026, retirement, wrapping up 22 years of incredible success. Kanagy came to SME when the Society was struggling financially and suffering decreasing membership. He and his staff completely turned around this bad situation and have established SME as the indisputable leading mining professional society.

We now have the financial resources to sustain our programs and the financial capacity and organizational ability to develop new programs. And, our membership is significantly growing. We are now focused on the imperative to hire an ED who will maintain and even increase SME's momentum.

Consistent with his dedication to SME, Kanagy gave us nearly two full years' notice of retirement, providing us the luxury to make and execute an effective transition plan with plenty of time. Marc LeVier, Marc Herpfer, Dave Kanagy and I met in June 2023 in Chicago to develop the go-forward plan and timelines with the goal of having a new executive director in place to overlap Kanagy's last few months.

Mary Korpi, 2026 SME President, was asked to chair the ED search committee, which consists of 10 members with Karin Harrington, SME's Director of Human Resources, providing us strong assistance. The committee is presently busy with sequential interviews and candidate evaluations. I can report that the committee has been making good progress and, at this point, qualified solid candidates are under consideration and we are on schedule.

In addition to that critical task, the SME Board has initiated consideration of the mega issue: "What programs can SME develop or

Safety Share | As spring arrives, wildlife becomes more active around mining sites. This increased activity can pose safety risks for miners. Here are some key tips to ensure safety:

- Be aware of your surroundings. Wildlife such as bears, snakes and insects may be more prevalent.
- Be mindful of entering buildings where wildlife may have made a winter home. Hantavirus, a respiratory disease transmitted through animal waste may need to be a consideration.
- Keep food and waste properly stored to avoid attracting animals.
- Do not approach or feed wildlife. Immediately report any wildlife sightings to your supervisor or department responsible for monitoring wildlife activity.
- Wear appropriate protective clothing and gear, especially in areas known for wildlife activity. ■

emphasize to support our membership and industry." Mega issues are a broad range of strategic opportunities and issues impacting SME that are driven by professional, industry and societal changes. SME must respond to these to ensure we are maximizing benefits and relevance. The board will discuss strategic plans and initiatives in collaboration with our corporate partners and members, which will also inform our planned 2026 Board Strategic Planning update.

After identifying the programs the SME Board would like to pursue, they will be given to standing and ad hoc committees to evaluate and establish tactical plans if they are found to be worthwhile to SME and the mining industry.

For many years, beginning with my first job at Cleveland-Cliffs, I enjoyed reading the *Paydirt* and *Skillings* magazines, which were basically consolidators of mining news and developments. While *Paydirt* is no longer published, I have fond memories of the musings and mine and project developments coverage column called the One Eyed Explorationist. Dan Eyde informed me this column was ghostwritten by Ben Dickerson. He used a salutation that I will be using as a warm echo from the past:

Deep Enough! ■

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Military bases could serve as mineral refining locations

U.S. PRESIDENT DONALD Trump aims to build metals refining facilities on Pentagon military bases as part of his plan to boost domestic production of critical minerals and offset China's control of the sector, two senior administration officials told *Reuters*.

The move is one of several planned for an executive order Trump could sign after he told the U.S. Congress he would "take historic action to dramatically expand production of critical minerals and rare earths here in the USA."

As part of the order, the Pentagon would work with other federal agencies to install processing facilities on its bases, according to the sources, who were not authorized to publicly discuss the administration's deliberations.

Using military bases for processing would underscore the importance Trump is placing on critical minerals for national security. Fighter jets, submarines, bullets and other weaponry used by the U.S. military are built with minerals processed by Beijing.

Trump also plans to name a critical minerals czar, similar to steps previous presidents have taken to coordinate Washington's focus on other areas, according to one of the sources. The plans are under discussion and could change before Trump signs the order,

the sources added.

Some Trump administration officials were spooked by initial signs that China might restrict critical minerals exports as part of its retaliation for Trump's tariffs or for other reasons, according to a person familiar with their thinking. The U.S. National Security Council did not respond to *Reuters* for requests for comment.

With the Pentagon controlling about 30 million acres of land, the plan would ensure there is available land for the refining facilities, avoiding the controversy that sometimes occurs in host local communities. It would also avoid the need to buy land and avoid using land controlled by other federal departments.

A plan that prioritizes metals processing — rather than an overhaul of U.S. mine permitting — could irk U.S. miners but address a longstanding concern from manufacturers that China controls too much of the global metals processing sector. China is a top global producer of 30 of the 50 minerals considered critical by the U.S. Geological Survey, for example.

It is not clear how Trump's plan for processing facilities on Pentagon bases could work from a regulatory

perspective, as the U.S. Clean Air Act and Clean Water Act would still apply to Pentagon bases and those regulations have hindered private development of processing projects in the past.

Trump previously signaled a willingness for alternative uses of lands controlled by Washington. As a presidential candidate, he pledged to open up portions of federal land for large-scale housing construction, with zones that would be "ultra-low tax and ultra-low regulation."

Trump does not plan in the order to establish a U.S. critical minerals stockpile that would mimic the Strategic Petroleum Reserve, the sources said, a step that some in the administration and mining industry had sought. China stockpiles some critical minerals, including cobalt, and the U.S. government last year considered stockpiling the metal, which is used in missiles, aerospace parts, magnets for communication, and radar and guidance systems.

Trump also does not plan to order the Pentagon or other U.S. agencies to require vendors to use only U.S. minerals, what is known as a "Buy American" mandate, and one that junior miners have said is needed to offset China's market manipulations. ■

US interior secretary urges more drilling and mining

U.S. INTERIOR SECRETARY

Doug Burgum told energy executives that he wants their industries to ramp up drilling and mining on America's public lands, telling the crowd: "We love you!" *Reuters* reported.

Burgum's comments to the CERAWeek energy conference in Houston, TX underscored the agenda of President Donald Trump to unfetter fossil fuels and metals production by slashing as much red tape as possible.

"If we're going to drill, baby, drill, then we've got to be asked to also mine, baby, mine," Burgum, a former governor of the oil-producing state North Dakota, told the crowd.

He said royalty payments to the government from drillers and miners operating federal lands and in U.S. waters will help pay down the national

debt. Oil and gas drillers operating on federal lands paid about \$75 billion from 2012 to 2022, according to the Government Accountability Office. The national debt, by comparison, is now about \$36.2 trillion.

U.S. oil and gas production struck record highs under the administration of former President Joe Biden, and it was unclear if energy companies are keen to ramp up investment with oil prices plumbing three-year lows.

Burgum said he believes the Trump administration can unwind between 20 and 30 percent of the country's regulations, and estimated that doing so could sharply cut the cost of producing oil. He added that speeding up energy and mining project permitting would be a crucial focus of the administration's National

Energy Dominance Council, which he chairs and which is responsible for coordinating government policies to maximize production.

Burgum said boosting U.S. electricity generation and transmission capacity is key to winning what he called the "AI arms race" with China.

Burgum added that he believes enforcing sanctions on Iran, which are designed to bring the OPEC member's oil exports to zero, could end that country's funding of "terror groups."

He added that the council is focused on boosting U.S. production of critical minerals, which include lithium and nickel. He said the council has "really big, really powerful" ideas to boost U.S. mining, including using the planned U.S. sovereign wealth fund and better coordinating with allies. ■



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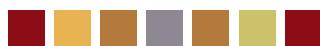
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Industry Newswatch

ICMM publishes new guidance to help mining and metals companies protect and restore biodiversity

ACCORDING TO THE 2024 Living Planet Report, wildlife populations have seen a 73 percent average decline from 1970 through 2020, largely driven by climate change, deforestation, habitat loss, hunting, overfishing and other environmental impacts of food production. While the industry is dependent on the essential services provided by healthy ecosystems — such as reliable access to clean water, erosion prevention and flood control — mining operations often intersect with areas of high biodiversity value and have also historically played a significant role in environmental degradation. Therefore, protecting and conserving nature is not just a responsibility — it is a business imperative.

“Nature and biodiversity loss are a critical global challenge, placing the well-being and livelihoods of people, ecosystems and our global economy at significant risk,” said Hayley Zipp, director of environment at ICMM. “Committing to achieve no net loss or net gain of biodiversity at mining and metals operations is essential for our industry to contribute to the global goal of halting and reversing nature loss.”

ICMM’s Good Practice Guide for

Achieving No Net Loss or Net Gain of Biodiversity outlines a seven-step process, applicable at each stage of the mining lifecycle from a project’s design to post-closure and production, to help companies establish baseline assessments, apply the mitigation hierarchy and transparently disclose progress toward their no net loss, or net gain, goal. It is a technical resource designed for practitioners at site level and corporate professionals overseeing sustainability and biodiversity strategies to help scale and accelerate the implementation of these approaches across the industry.

ICMM’s guidance builds on decades of experience and lessons learned by their members in rehabilitation, restoration and no-net-loss strategies. By integrating real-world examples and global insights, the guidance can help mining and metals companies, regardless of their size, maturity level or location, achieve no net loss or net gain of biodiversity.

“But we must go further. Building a nature-positive future requires multi-stakeholder collaboration, innovation and accountability,” said Zipp. “That’s why our members have committed to

taking nature action across the value chains, landscapes and systems we operate in. We urge companies across the industry — and those managing significant land areas in other sectors — to take the lead in making commitments that help protect and restore nature for the benefit of all.”

The new guidance aims to help ICMM members achieve their direct operation commitments set out in ICMM’s nature statement. Guided by the Kunming-Montreal Global Biodiversity Framework and shaped by experts and leaders from across industry, civil society, Indigenous Peoples groups and finance, the position statement signifies a collective promise to contribute to a nature positive future across four areas of influence: direct operations, value chains, landscapes and systems transformation.

Commitment 1.3 of the statement requires achieving no net loss or net gain of biodiversity by closure for all existing mining operations from a 2020 baseline or earlier, and for all new operations and significant expansions against a pre-operation or pre-expansion baseline, respectively. ■

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Gold rally attracts investors back to mining stocks after months of growth

FUNDS THAT INVEST in gold miners are set to attract their largest net monthly inflows in more than a year in March, as record-high gold prices improve firms’ profit outlooks and boost cash flow, *Reuters* reported. Although gold prices also rose last year, miners still struggled to offset inflation-driven spikes in labor and fuel costs while facing regulatory hurdles such as tax disputes in Mali and project delays in Canada. As a result, investors mostly shunned equity funds focused on gold miners, opting instead for traditional gold funds that offered a safe haven during the Russia-Ukraine war and escalating trade tariff concerns after Donald Trump won the U.S. election in early November.

According to LSEG Lipper data, funds investing in physical gold and gold

derivatives attracted a net \$17.8 billion in 2024, the highest in five years, while funds investing in gold miners lost a net \$4.6 billion, the most in a decade.

With gold up more than 15 percent this year to a record high above \$3,000 an ounce, investors are more optimistic that miners can absorb higher costs, expand margins and generate stronger cash flows. Shares of top miners such as Newmont and Barrick Gold, have more than reversed 2024 falls of 10 percent and 7 percent, respectively, surging around 27 percent and 21.5 percent so far this year.

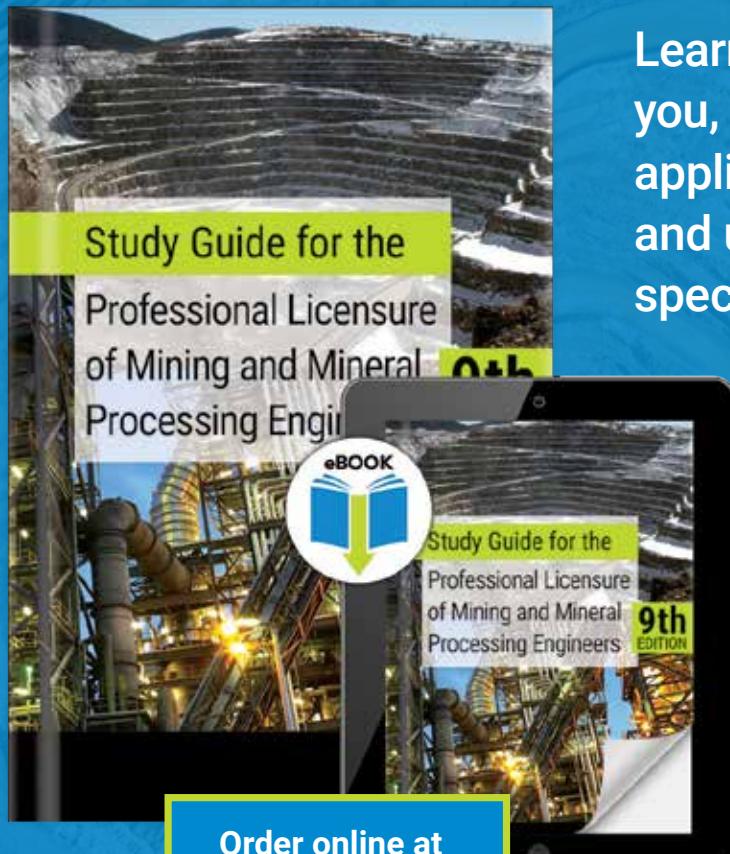
Funds targeting gold miners drew their first net monthly inflow in six months in March, according to Lipper data, attracting \$555.3 million, the highest since November 2023. ■

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Industry Newswatch

Epiroc wins large order for battery-electric vehicles for Hudbay Minerals' gold and copper mine in Canada

EPIROC AB has won a large order from Hudbay Minerals Inc. for a fleet of battery-electric vehicles (BEVs) to be used at an underground mine in Canada.

Hudbay Minerals, Canada's third-largest copper producer with nearly a century in operation, has ordered BEV versions of the Boomer M20 SG face drilling rig, the Scooptram ST18 SG and Scooptram ST14 SG loader, and the Minetruck MT42 SG hauler. The machines will be used to strengthen productivity and work conditions while lowering emissions at the Lalor Mine in Snow Lake in Manitoba, where Hudbay Minerals extracts gold, copper, zinc and silver.

"We are happy to support Hudbay Minerals as it takes its next step on its electrification journey," said Helena Hedblom, Epiroc's president and chief executive officer. "There

are clear benefits to our customers that invest in electrical equipment. It improves the health of the employees, saves ventilation costs and reduces greenhouse-gas emissions. In addition, our battery-powered equipment also outperforms the productivity of corresponding diesel equipment."

The order is valued at around MSEK 100 and was booked in the first quarter of 2025. In addition to the equipment, Epiroc is providing aftermarket support such as service and rock drilling tools.

Hudbay Minerals has operated a battery-powered Epiroc Scooptram loader for the past several years, successfully testing the technology in close collaboration with Epiroc.

"Expanding our BEV fleet at Lalor is a cornerstone of our Green Revolution strategy, driven by the tangible benefits we've seen, including

significant greenhouse-gas reductions, improved operator satisfaction and lower maintenance costs," said Rob Carter, vice president of Hudbay Manitoba Business Unit. "Our strong partnership with Epiroc, who provides exceptional support and truly invests in our success, made this BEV fleet expansion a logical and responsible choice."

Delivery of the machines to the Lalor Mine will take place between the first and third quarters of 2025.

Epiroc has been awarded orders for BEVs to a total of 39 mine sites around the world. Around a third of the mines with BEVs in production have already placed repeat orders.

Epiroc provides a full range of electrification solutions, including competence, infrastructure, cable-electric machines, battery chargers, maintenance and recycling. ■

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Industry Newswatch

Russia plans to launch large-scale lithium production in 2030 to reduce import dependency and raise battery output

RUSSIA PLANS to produce at least 60 kt (66,000 st) of lithium carbonate in 2030, the country's natural resources ministry said, as Moscow seeks to reduce its dependency on imports and boost production of high-capacity electric batteries, *Reuters* reported.

Lithium and other critical minerals, including rare earth metals, have gained global attention in recent months, as U.S. President Donald Trump aimed to counter China's dominance in the sector by offering production deals to Ukraine and Russia.

Lithium, a metal essential for electric-vehicle production, is included on the list of 50 minerals deemed critical by the U.S. Geological Survey. Russia reported having 3.2 Mt (3.5 million st) of lithium oxide reserves.

The U.S. Geological Survey estimated Russia's lithium reserves at

about 907 kt (1 million st) in 2024, the world's 14th largest. Lithium oxide has about one third of pure lithium, and lithium carbonate contains about 20 percent of pure lithium.

"Industrial lithium production in the country will begin in 2030," the ministry stated.

President Vladimir Putin said that Russia should speed up its plans to mine lithium deposits.

Demand for lithium has surged in recent years as Russian companies work on the mass production of lithium batteries and electric vehicles.

"The country has traditionally imported lithium, and it is now crucial to launch facilities swiftly and increase the extraction and processing of this strategically important resource for the economy," the ministry added.

The ministry said it had issued exploration licenses for three major

lithium deposits: Kolmozerskoye and Polmostundrovskoye in the Murmansk region in northwestern Russia, and Tastygskoye in the Tuva region, which borders Mongolia. All three deposits and their adjacent production plants are expected to become operational by 2030, the ministry said. In 2023, Russia mined only 24.5 t (27 st) of lithium as a byproduct at an emerald deposit in the Ural Mountains.

Kolmozerskoye, which contains one-quarter of Russia's known lithium reserves, is operated by Polar Lithium, a joint venture between Russian metals giant Nornickel and the state-owned nuclear energy firm Rosatom. The private firm Arctic Lithium holds a license for Polmostundrovskoye, while Elbrusmetall-Lithium, a subsidiary of the state defense and industrial conglomerate Rostech, holds a license for Tastygskoye. ■

Trump seeks to boost critical mineral production by invoking emergency powers, in effort to offset China

U.S. PRESIDENT Donald Trump invoked emergency powers to boost domestic production of critical minerals used widely across the economy as part of a broad effort to offset China's near-total control of the sector, *Reuters* reported.

The move is the latest by Trump to increase U.S. energy and minerals production and comes amid an escalating trade conflict with China, Canada and other large minerals producers that supply American manufacturers.

Lithium, nickel and other critical minerals are used in many electronics, and demand is expected to surge in coming years for the production of electric-vehicle batteries. China is the world's largest producer or processor of many critical minerals.

Trump signed an executive order that taps the Cold War-era Defense Production Act (DPA) as part of an effort to provide financing, loans and other investment support to domestically process a range of critical

minerals. The DPA gives the Pentagon wide berth to procure equipment necessary for national defense. Invoking it essentially declares that relying on rival nations for critical minerals constitutes a national security threat. "The United States was once the world's largest producer of lucrative minerals, but overbearing federal regulation has eroded our nation's mineral production," the president said in the order.

The order directs federal agencies to create a list of U.S. mines that can be quickly approved as well as which federal lands, including those controlled by the Pentagon, could be used for minerals processing.

The United States currently produces very little lithium and nickel; its only cobalt mine shuttered last year amid intense Chinese competition. It does have multiple copper mines, but only two smelters to process the red metal into pipes, wiring and other components. It has only one mine for rare earths, which are used to make

magnets that turn power into motion.

Late last year, Beijing imposed an outright ban on exports of gallium, germanium and antimony to the United States, causing U.S. manufacturers to scramble for alternative supplies of those niche-but-vital materials.

The order also encourages faster permitting for mining and processing projects and a directive for the Interior Department to prioritize mineral production on federal land. The order directs agencies to help boost U.S. output of copper and gold, neither of which is considered a critical mineral by the U.S. Geological Survey.

An executive order from Trump had long been sought by U.S. miners, many of which had long complained that bureaucratic delays hampered output. "Ramping up American mining is a national security imperative, and President Trump's strong action recognizes that," said Rich Nolan, head of the National Mining Association trade group. ■

Freeport-McMoRan hopes President Trump declares copper a critical mineral to boost production

FREEPOR-TMCMORAN hopes U.S. President Donald Trump declares copper a critical mineral, a move that would unlock tax credits needed to boost American production of the red metal and offset global rivals, chief executive officer Kathleen Quirk said, *Reuters* reported.

Trump told the U.S. Congress he would “take historic action to dramatically expand production of critical minerals,” although he has yet to provide details. Copper is used widely across the global economy in power generation, electronics and construction.

The U.S. Geological Survey lists lithium, nickel and 48 other minerals as critical. Adding copper would help Freeport generate more than \$500 million annually in tax credits tied to the U.S. Inflation Reduction Act, Quirk told *Reuters* on the sidelines of the CERAWeek energy conference in Houston, TX.

“Having the incentives and clarity around those would be a big plus for the domestic copper industry,” said Quirk, who became chief executive officer of Phoenix-based Freeport last year. “People are understanding more what copper is used for and its importance in our economy. It’s just a matter of time before it’s classified as a critical mineral.” Former President Joe Biden’s administration extended the tax credit to critical minerals last October. Copper producers cannot access it unless their product is labeled as critical.

All the copper that Freeport produces at its seven U.S. mines is consumed domestically, making it the country’s largest producer of the metal. Freeport also operates one of two U.S. copper smelters and produces more than 200 million pounds of the metal annually using leaching.

The average grade, or percentage of copper in rock deposits in Freeport’s U.S. mines, is lower than elsewhere, boosting costs and making the United States Freeport’s least profitable region.

“We’re not looking for handouts, but if the government is trying to

incentivize domestic production, it’s important to recognize that the U.S. doesn’t have the same grades that we have internationally,” said Quirk.

In February, Trump launched a probe into potential new tariffs on copper imports to help rebuild U.S. production. U.S. copper tariffs could boost Freeport’s profits by \$400 million annually, yet the company is worried about their impact on the global economy, Quirk said.

“We’re not out there advocating one way or the other. We’re wanting to make sure that there’s education so that there’s informed decisions about all of this,” Quirk said.

In Indonesia, where Freeport operates the Grasberg copper and gold mine, Quirk said the company expects to reach an agreement soon with Jakarta that would allow copper concentrate exports by the end of the month.

Elsewhere, Trump has expressed interest in minerals projects in Greenland and Ukraine. Quirk said Freeport would “always look” at potential international investments, but that Greenland and Ukraine are “not on our near-term priority list.”

The U.S. State Department said it was open to exploring critical minerals partnerships with the Democratic Republic of the Congo (DRC), which is rich in cobalt, lithium and other minerals. Freeport sold its DRC operations in 2016 but is eyeing a return, Quirk said.

“We would be interested in going back (to the DRC) for the right opportunity,” said Quirk, adding that would mean Freeport would be the operator of any mine. Quirk declined to comment when asked if Freeport is in negotiations with the DRC government. ■



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Industry Newswatch

USGS projects world production capacity for seven critical minerals and helium from 2025 to 2029

THE U.S. Geological Survey (USGS) released projections for world production capacity for seven critical minerals and helium for the next five years in the first World Minerals Outlook, a forward-looking assessment that is part of a larger effort to provide forecasts and scenarios for global mineral supply chains.

The world's capacity to produce cobalt and lithium, two elements critical to the batteries used to power mobile devices, tools and vehicles, is expected to double over the next five years. Capacity for gallium, palladium, platinum and helium is expected to remain stable.

"The USGS scans the horizon for future supply-chain risks across a broad range of minerals, informing supply-chain strategies ranging from mapping domestic mineral resources to recycling and reprocessing mine waste," said Sarah Ryker, acting USGS director. "The World Minerals

Outlook makes more of that foresight into future trends available publicly for U.S. leaders, other federal agencies, industry and the public."

This first World Minerals Outlook is part of the USGS' mission to produce multiyear forecasts of the production, consumption and recycling patterns of all 50 critical minerals, as directed by the Energy Act of 2020. In 2017, Executive Order 13817 A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals defined critical minerals as those essential to the U.S. economy and national security and with a supply chain vulnerable to disruption and directed the USGS to develop the whole of government List of Critical Minerals. Earlier this year, Executive Order 14154 Unleashing American Energy emphasized that role.

The World Minerals Outlook methodology pulls from multiple rich data sets that USGS produces

and analyzes, as well as from the expertise of USGS mineral specialists. It considers announced, funded projects in evaluating future capacity based on when they may come online; subtracts operations nearing the end of their announced life or with depleted resources; and accounts for idled capacity as available. When there are no available statistics for a plant or country's production capacity, it uses a conservative

approach that incorporates their actual production.

"The production capacity data in the World Minerals Outlook tells us where industry and the market are expecting demand will grow — as we see with lithium and cobalt. As U.S. leaders plan to increase domestic production of critical minerals to reduce reliance on non-market economies and mitigate risks, these data help identify where U.S. capacity may not meet demand," said Elisa Alonso, lead author of World Minerals Outlook.

In other findings, the first World Minerals Outlook noted:

- Magnesium projects outside China have lost funding or encountered other obstacles, and capacity globally is being idled.
- U.S. titanium sponge production capacity was idled and has resulted in the United States increasing its reliance on imports from Japan.
- Gallium is used in gallium arsenide and gallium nitride compound semiconductors. There is additional production capacity for gallium outside China with the potential to produce gallium in Germany, Kazakhstan and South Korea in response to China's gallium export ban to the United States.
- Cobalt production in the United States and North America has stalled due to price reductions by world market leader China, a phenomenon the USGS also examined in the 2025 Mineral Commodity Summaries.
- Palladium demand would decrease if the electric-vehicle market ramps up, as electric vehicles do not need catalytic converters. Domestic capacity for palladium mine and metal production could be further idled if prices remain low or drop farther. ■

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Panama's economic growth slows to 2.9 percent in 2024 after closure of Cobre Panama Mine

PANAMA'S GROSS domestic product grew 2.9 percent in 2024, significantly slowing from the previous year's 7.4 percent expansion, as air transport declined and a major copper mine closed, official data showed, *Reuters* reported.

In the last decade, Panama was one of the world's fastest-growing economies, but authorities had predicted a decline in growth, largely due to the closure of a copper mine operated by Canadian miner First Quantum, following clashes over First Quantum's tax contributions and

environmental impacts.

"Air transport experienced a decrease, as did the exploitation of mines and quarries, due to the closure of the copper mine operations," according to a report from the National Institute of Statistics and Census.

Panama's previous government in late 2023 ordered First Quantum to shut the openpit Cobre Panama Mine after many took to the streets protesting over environmental concerns. The mine was one of the world's top sources of copper,

accounting for 1 percent of global output.

The Central American country's economic growth in 2024 was mainly driven by sectors linked to international trade, such as the Panama Canal as toll revenue increased, and commercial activity in the Colón Free Trade Zone, the report said.

Among the internal sectors that recorded a positive performance last year were transport activities, construction, real estate and business and financial services, it added. ■

Rio Tinto backs London-Sydney dual-listed structure; asks shareholders to reject Palliser's resolution to review

MINING MAJOR Rio Tinto backed its dual-listed structure and asked shareholders to vote against London-based hedge fund Palliser Capital's resolution to review the firm's two listings in London and Sydney, *Reuters* reported.

The world's largest iron-ore miner said it had already conducted a robust and comprehensive review of the structure and had engaged with a number of stakeholders, including Palliser. It had previously recommended its London

shareholders to vote against the resolution.

"A dual-listed companies (DLC) unification is not required to provide the group with strategic flexibility," Rio Tinto said. A unification would be value destructive for the group and its shareholders, Rio Tinto flagged.

Rio Tinto will have its London annual shareholder meeting on April 3 and its Australian meeting in Perth on May 1.

Activist investor Palliser Capital and more than 100 other shareholders

in December sought a shareholder resolution calling for Rio's dual-listed model to be reviewed and urged the miner to keep only its listing in Australia. Their reasoning is that such a move would bolster the company's share price.

However, Australian shareholders are not keen for the move, as they say it would erode value.

Rival BHP ended a similar dual-listed structure in 2022 after pressure from activist investors and now has a primary listing in Australia. ■

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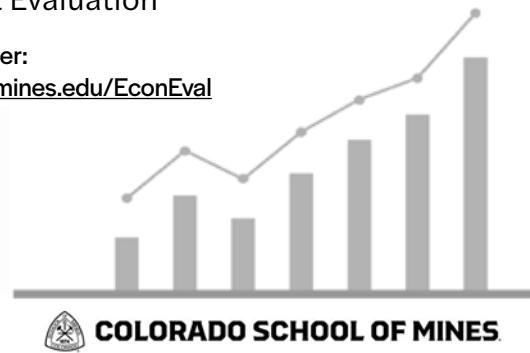
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Precipitation forecasting for tailings storage facility water management

by Homin Kim and Brant Whiting

Understanding precipitation accumulation patterns is critically important to ensure proper infrastructure design, water management planning and risk management, and reliably inform decision-making for mine management.

Statistical analysis of historical data is often used to forecast precipitation, but exclusive use of on-site weather station data is often insufficient because it does not consider regional climatology, and the period of record is usually limited. Further, while event-based risk (such as overtopping potential caused by a 100-year,

24-hour event) can be readily quantified, longer-term patterns are often only vaguely defined and generally not explicitly tied to probabilistic outcomes (for example: What if there is a wet year? What

if there are two wet years in a row because of El Niño?). Because of this, the ability to characterize both short- and long-term historic precipitation patterns and incorporate this into probabilistic forecasts using fewer statistical models and maximizing the information gained from existing data is of great interest. This case study generally explains how to overcome this constraint through the development of future daily precipitation sequences with exceedance probabilities for multiyear durations, and how these can be used to support decisions on tailings management. While there are several methodological advantages to this approach, ultimately, these improvements facilitate clear and reliable estimates of long-term, multiyear risks to decision-makers.

In this case study, site management needed to know not only what level of event-based precipitation accumulation would cause runoff

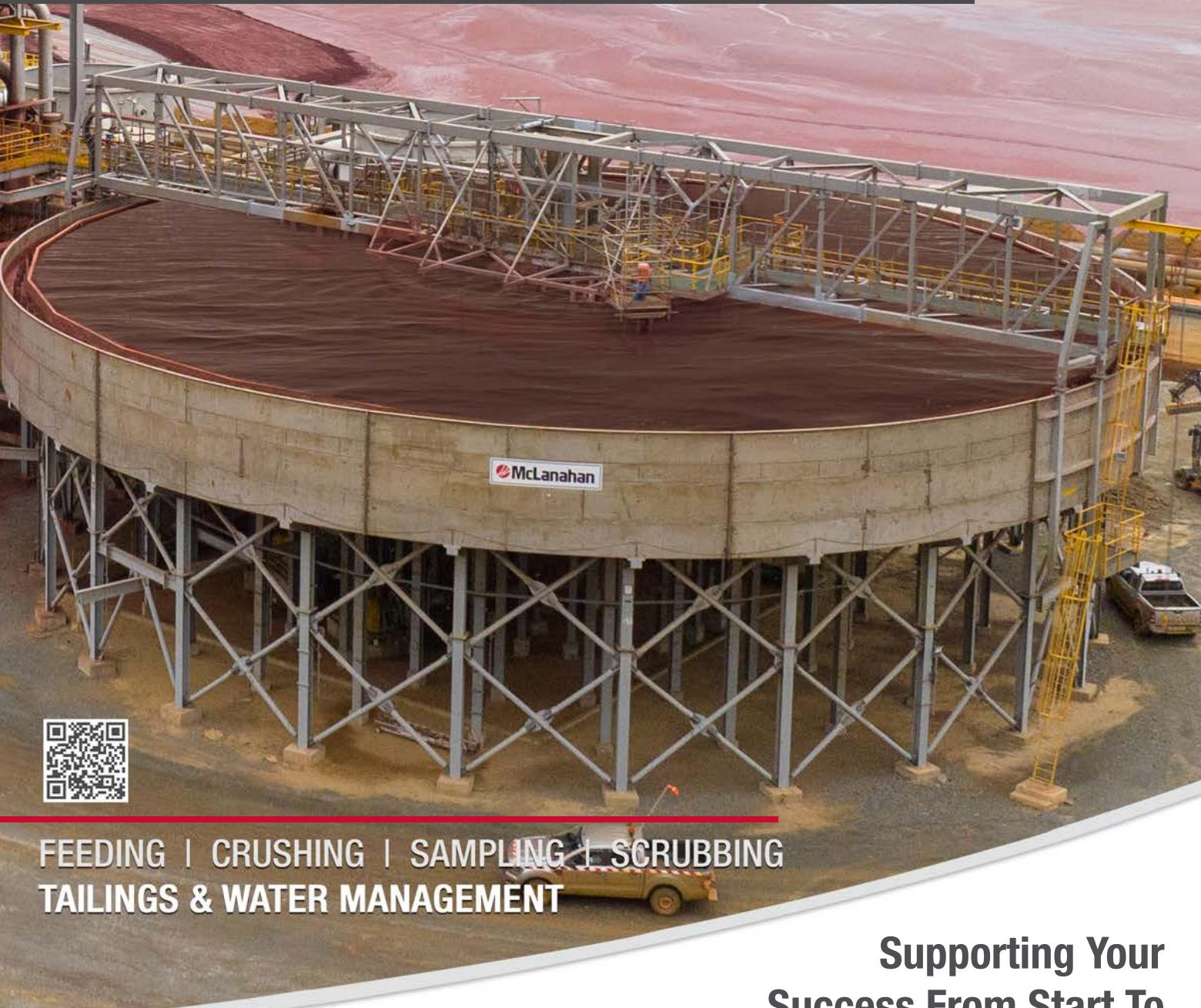
Homin Kim and Brant Whiting are senior engineer and manager engineering, respectively, at TCLW Water Resources, FM Technical Services, Freeport-McMoRan Inc., Phoenix, AZ, email hkim@fmi.com.



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Water Management

Table 1

Depth-duration-frequency example. (Source: Freeport-McMoRan)

Total precipitation as a function of duration and exceedance probabilities (EPs)					
EP (percent)	1 year (mm)	2 years (mm)	3 years (mm)	4 years (mm)	5 years (mm)
50	284	569	848	1,130	1,433
20	358	673	983	1,316	1,618
10	396	732	1,062	1,427	1,712
4	437	795	1,151	1,554	1,808
2	462	836	1,207	1,641	1,864
1	485	871	1,260	1,722	1,910
0.5	505	902	1,306	1,798	1,948

volumes to encroach on established freeboard requirements in a tailings storage facility — that is, event-based 100-year, 24-hour, 72-hour probable maximum precipitation (PMP) — but also how multiyear precipitation patterns (and their associated probabilities) could create adverse conditions that could impact operations and dam safety.

The facility evaluated in this case study has one on-site weather station, with a period of record limited to 12 years. Regionally, there

are 17 weather stations near the area of interest that are candidates to be incorporated into model forecast scenarios. After review of the 17 regional weather stations, two regional weather stations near the operating mine were chosen, using criteria such as a long period of record (more than 100 years at each weather station), data quality, reasonable distance from area of interest, and similar climatology. Following the selection of these quality-controlled regional weather stations, daily precipitation levels from the selected stations were aggregated into nonoverlapping n -year duration totals (such as one-year, two-year, up to five-year accumulation horizons). Goodness-of-fit and correlation measures between aggregated regional data and on-site measurements were used to identify the best distribution for developing the exceedance probability (EP) curves. These curves were used to derive a depth-duration-frequency table — Table 1 shows cumulative precipitation scaled to on-site conditions for various durations and EPs. For example, in a five-year duration, the data (more than 200 years of station data) indicate only a 0.5 percent probability of exceeding



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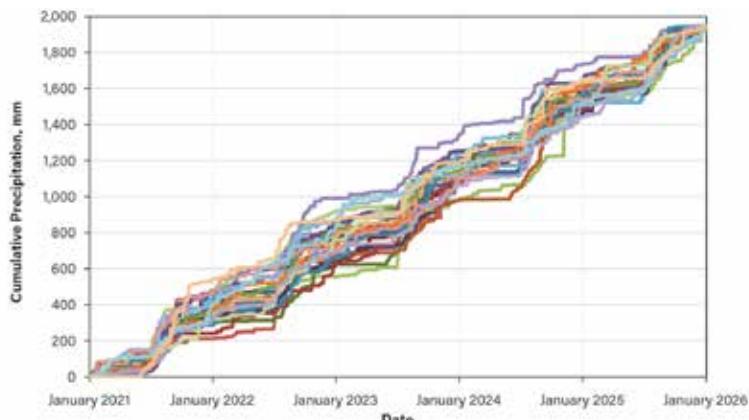
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Water Management

Figure 1

Thirty precipitation patterns to accumulate 1,948 mm of total precipitation for five years and a 0.5% exceedance probability. (Source: Freeport-McMoRan).



1,948 mm of total precipitation.

As a final step, 30 separate independent daily precipitation time series were extracted from the historical data for each EP and future duration based on how closely the cumulative precipitation in the sequence matched the respective EP precipitation total. Although we considered the selection of 30 time series in this example to be sufficient to capture the general

variability of accumulating precipitation to a given total, more sequences could be developed, based on the number of station-years available, and in some instances the number of sequences may be limited by the available gauge data periods of record.

An illustration of the five-year and 0.5 percent EP precipitation values is shown in Fig. 1. The selection of 30 different patterns provides a robust and data-based method of forecasting to account for variable temporal patterns to accumulate 1,948 mm and serves as a strong foundation for risk management and decision-making.

The technical benefits of such an approach are that patterns present in the long-term record near a site of interest can be used, thereby making it no longer necessary to explicitly model the independence and time-series correlations of precipitation patterns (such as Markov chains, independent monthly precipitation probability distributions) that are commonly used in water balance modeling forecasts.

From a management perspective, the first benefit of this approach is that site management was able to evaluate scenarios associated with different forecasted periods and their associated EPs, as shown in Table 1. The EP explicitly defines the probability of accumulating a certain amount of precipitation over a given time frame that is based on many station-years of data. A second benefit is that the EP and corresponding duration can be modeled using a variation of temporal patterns (30 sequences) to assess the systematic potential of exceeding a given criterion — for example, freeboard. Finally, this methodology allows the regional data to be used to their utmost and removes a requirement to statistically model climatologic patterns in model inputs. For example, this method intrinsically accounts for month-to-month and year-to-year correlations because of extended dry/wet periods caused by macroscale climate events. These patterns are very difficult to explicitly model, and any month-to-month and year-to-year patterns that emerge from modeling the climate series as independent monthly probabilities would only be random rather than part of a longer-term signal that is present in the regional data.

To address the concern of site management regarding the likelihood of exceeding a freeboard limit, seven

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Table 2

Summary of all 1,050 simulations with number of precipitation patterns from 30 sequences by three categories. (Source: Freeport-McMoRan)

Category	Likelihood of exceeding freeboard criteria (Green = Unlikely, Yellow = Potentially, Red = Likely)				
	Exceedance probability (percent)	1 year	2 years	3 years	4 years
50	1	1	2	2	0
20	1	1	0	4	1
10	1	1	1	0	3
4	1	1	2	1	1
2	3	2	1	1	2
1	5	4	2	4	1
0.5	9	4	5	6	1

recurrence probabilities and five-time horizons (35 scenarios), shown in Table 1, were modeled, each using all 30 precipitation scenarios in GoldSim, version 12.1 (Gold Technology Group, Seattle, WA, 2020). This required 1,050 simulations. Furthermore, the simulations included a 72-hour PMP event during the later months of the simulation period.

The summary of simulations can be seen in Table 2. To determine freeboard exceedance, there are three categories: (1) Unlikely, in green, (2) Potentially, in yellow and (3) Likely, in red. Unlikely is used when the average of 30 sequences does not exceed the criteria, and fewer than five sequences do exceed the criteria. Potentially is assigned when the average of 30 sequences does not exceed the criteria, but a total of five or more individual sequences exceeds the criteria. Likely represents the condition when the average of the 30 sequences exceeds criteria. Of the 35 scenarios, all but four were determined unlikely to exceed the minimum freeboard criteria of 1.5 m. The remaining four scenarios were estimated to potentially exceed the criteria. For the four potential cases highlighted in yellow, the numbers given represent the number of sequences out of 30 that exceed the criteria: The overall average freeboard for the 30 sequences did not exceed the criteria in these cases.

Together, these results show that the current operating practices at the site are adequate to safely manage extreme multiyear precipitation accumulations combined with the 72-hour PMP for all durations at the 2 percent EP and greater. For the 1 percent and 0.5 percent EPs, the results show there is a potential for the freeboard criteria to be exceeded (for example, instead of 1.5 m of freeboard, the facility only has 1.3 m of freeboard) for the one-, three- and four-year durations, but only after a very low probability (1 percent, 0.5 percent) precipitation pattern and a rare extreme storm event: that is, PMP.

Regional precipitation analysis is designed for use in generating daily precipitation patterns that are representative of future precipitation levels at a site. Utilizing data from regional weather stations overcomes the limitations of on-site data and quantifies the uncertainty over various durations. More importantly, the results in this case study indicate that the proposed

approach reflects actual daily precipitation patterns and can be used to quantify risk going forward. Taken together, these findings significantly improve the capacity to forecast precipitation and can improve water management practices in the planning stages. This enables site managers to make proactive and informed decisions in consideration of precipitation accumulation patterns as well as extreme events, and their combinations. ■

Editor's Note: This case study was originally published in the book "Tailings Case Studies: Real-World Lessons in Tailings Management," edited by Kimberly Finke Morrison and published by the Society for Mining, Metallurgy & Exploration, 2024. Available at <https://store.smenet.org/>



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Komatsu presents innovation in motion during Quarry Days 2025

by Carrie Smith, Associate Editor

Photo courtesy of Komatsu



Intelligent quarry management with the Smart Quarry Site platform was a prevalent theme in Komatsu's Quarry Days event.

Deep in the heart of Sahuarita, AZ lies Komatsu's 660-acre Arizona Proving Grounds (AZPG), where cutting-edge mining and construction equipment is put through its paces. Through its newly founded tradition called Quarry Days — an event that offers dealers and customers the opportunity to operate Komatsu mining and construction equipment — Komatsu provides patrons with the opportunity to learn about the latest technological innovations the company possesses.

This exclusive event brought industry leaders, dealers and media together over the course of two weeks in February for an immersive experience surrounding the latest innovations that are shaping the future of mining operations. Spectators had the opportunity to witness live demonstrations, interact with product experts and operate state-of-the-art machinery.

Komatsu has long been at the forefront of technological advancement in mining and construction equipment, and Quarry Days offered attendees an inside look at the company's latest advancements. From autonomous haulage solutions to high-powered wheel loaders, this year's event highlighted efficiency, productivity and sustainability in modern quarry operations.

During Quarry Days, Komatsu spotlighted

several new and enhanced machines, each designed to maximize productivity and reduce downtime. Among them was the HD605-10 mechanical haul truck, engineered for durability and efficiency with improved horsepower, faster uphill speeds and Smart Quarry Site integration for remote jobsite monitoring. It also featured Pronto AI's autonomous haulage technology, currently being piloted in Texas.

Designed to seamlessly pair with the HD605-10, Komatsu showcased the WA700-8 wheel loader, a powerhouse offering enhanced lifting force, an advanced joystick steering system and automation features that streamline repetitive tasks. Another wheel loader featured was the WA900-8, designed to match Komatsu's 100-ton HD785-8 haul truck, delivering enhanced breakout force and Smart Quarry Site compatibility for real-time monitoring and performance tracking. Other haul trucks featured were the HD785-8 and HD1500-8E0 mechanical haul trucks, which offer superior payload capacities and innovative transmission systems to optimize fuel consumption and minimize material spillage.

One of the captivating highlights of Quarry Days was Komatsu's demonstration of Pronto AI, an autonomous haulage solution for quarry-sized trucks. Pronto's vision-based autonomy

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Mining Equipment

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Quarry Days gives attendees an opportunity to witness live demonstrations, interact with product experts and operate state-of-the-art machinery.

system eliminates the need for expensive lidar sensors, making automation more accessible for quarry operators. By reducing the need for human drivers, Pronto AI technology helps quarries address labor shortages while increasing productivity by up to 20 percent per truck.

Komatsu used Pronto AI in front of spectators to autonomously operate the WA700-8 wheel loader and the HD605 mechanical haul truck. During the demonstration, the WA700-8 scooped up to a heap of dirt, as the HD605 haul truck backed up into formation, perfectly placing its bed under the dozer's arm. The wheel loader dropped the pile of dirt into the bed of the HD605, which then proceeded to drive off. The entire presentation was controlled by the connected Pronto AI system, located directly in front of the audience.

In relation to dozers, the D475A-8 surface mining dozer also made an appearance, revealing its build for longevity and productivity, and featuring a robust mainframe engineered for multiple rebuild cycles. The D475A-8 also encompasses an advanced traction system that increases pushing power and ripping efficiency. Pairing nicely with the dozers were the excavators, showcasing the PC2000-11 excavator, which boasts increased horsepower

and a redesigned hydraulic system. Its hydraulic system enables faster cycle times and superior performance in stripping applications and overburden removal, giving it an advantage compared to other machinery.

Portraying versatility on difficult terrain was the HM400-5 articulated truck, showing a viable option with an automated traction control system to ensure seamless operation in challenging underfoot conditions. Following suit for haul road maintenance solutions was the GD955-7 motor grader, engineered for precision and featuring an 18-ft moldboard with up to 33 percent increased productivity over previous models.

Focusing on sustainability, the HB365LC-3 hybrid excavator stood out for its energy efficiency, reducing fuel consumption and carbon dioxide emissions by up to 20 percent, and an intelligent energy recovery system that optimizes digging cycle times. The ZT44 drill was also available on site, demonstrating its build for longevity and precision due to providing reliable performance in extreme environments with a high-pressure compressor and flexible drilling depth capabilities. In addition, the Stamler RF-5 reclaim feeder was visible, highlighting its modular, cost-efficient material blending and feeding system designed for seamless integration into cement plants, ports, refineries and mines.

Along with highlighting new equipment and its autonomous operating systems, Komatsu is currently pushing the boundaries of intelligent quarry management with its Smart Quarry Site platform, a system that was prevalent throughout Quarry Days. Designed to optimize fleet operations, Smart Quarry Site provides real-time data on fuel consumption, idle time and machine utilization, helping operators maximize efficiency and reduce costs.

As Komatsu continues to refine its equipment offerings, the company has already developed new machines set for release this year. These upcoming models promise further advancements in efficiency, automation and sustainability, aligning with Komatsu's vision of an empowered, eco-conscious mining industry.

With Quarry Days 2025, Komatsu reaffirmed its commitment to innovation, customer collaboration and sustainable mining solutions. Attendees left not just with insight into the latest advancements but with firsthand experience of the future of quarry operations. As technology evolves, it is clear Komatsu is contributing to a smarter, safer and more efficient industry. ■

Inside MINEXCHANGE 2025:

Industry innovations, insights and future trends

by Carrie Smith, Associate Editor and William Gleason, Editor

The MINEXCHANGE 2025 SME Annual Conference & Expo took place Feb. 23-26 in the Colorado Convention Center in Denver, CO, bringing together professionals from across the mining and minerals industry for a dynamic exchange of ideas and innovations. The conference extended over three days, showcasing an exhibit hall featuring a plethora of booths, gadgets, innovations and industry knowledge set against an informative and compelling program of keynote, plenary and technical sessions, short courses, and social and off-site events.

Artificial intelligence (AI) in the industry

The conference kicked off with a high-energy keynote session led by business executive and artificial intelligence (AI) strategist Terry Jones on "AI: Innovation and Disruption — The Path Forward," which offered insights into how AI can revolutionize traditional mining practices. Sponsored by South32, the conference commenced with remarks from South32's chief executive officer Pat Risner, followed by Colorado Mining Association president Adam Eckman and 2024 SME President Mark Herpfer.

Once the stage was set, Jones took the audience on a deep dive into the transformative power of AI and its implications for the mining industry.

Jones, a pioneer in travel technology with a background at American Airlines, Travelocity and Kayak, captivated the audience with an engaging narrative on innovation, disruption and connectivity. He set the tone with a storytelling approach, referencing Ernest Hemingway's novel *The Sun Also Rises* to illustrate how change often happens gradually, then suddenly. AI, he argued, is that kind of change, gradual in its development but now at the tipping point of revolutionizing industries, including mining.

Jones pointed to the fundamental ways AI has already reshaped industries, from ridesharing to hospitality, and emphasized how mining is next in line for disruption. Despite being the third most impacted sector, mining remains behind in AI investment, presenting a critical opportunity for those ready to embrace change.

AI has been around for decades, but Jones outlined three key enablers of its recent explosive growth. Computing power has surged, allowing AI models to process and interpret

Artificial intelligence (AI) strategist Terry Jones led the keynote session on "AI: Innovation and Disruption — The Path Forward."



MINEXCHANGE Recap



The expansive exhibit hall showcased cutting-edge products, services and integrated solutions.

complex data sets quickly. He mentioned that its ability to collect, store and analyze vast amounts of information has grown exponentially, giving rise to complex generative and agentic AI systems. Jones stressed the importance of data integration, explaining that AI is most valuable

when it can synthesize unstructured data to provide insights and make informed predictions.

Contributing to the forefront of modern technology, mining companies are beginning to implement AI to enhance efficiency, safety and sustainability. Jones highlighted real-world examples of AI in action, such as AI-driven autonomous systems reducing human exposure to hazardous environments, Internet of Things (IoT)-enabled predictive analytics preventing costly downtimes, methane sniffing drones

improving environmental safety and Holcim's AI-powered concrete ordering system. He also touched on the growing role of AI in customer service, supply-chain management and 3D printing. Mining companies, he argued, should look beyond their industry and "connect the dots" from other sectors where AI has already driven substantial transformation.

While AI offers immense potential, Jones acknowledged the challenges that come with adoption, including outdated or incomplete data sets, cybersecurity risks, workforce transitions and the need for thoughtful implementation into business models. He closed with a challenge to the audience: "AI is going to be in everything. How will you put it in your enterprise?" Jones' insights serve as a powerful reminder that AI is not just a tool for efficiency, it is a game changer poised to redefine the mining industry.

The AI discussion continued during the SME Health & Safety Division Awards Breakfast when Matt Law, a leader in public health, environmental health, occupational safety, security, business continuity and sustainability, spoke about AI and its health and safety applications.

Law, an experienced researcher and speaker with extensive AI experience, provided a comprehensive overview of AI before speaking about how AI can help health and safety professionals improve their processes as well as providing guidance for the use of AI.

"AI is not going to fix bad data," said Law. "If you have bad model training, or if you are already doing compensating the wrong way, AI is going to learn that and build on that and you will continue to have the same problems."

The advertisement for Somerset International features the company's logo, which is a stylized 'S' composed of blue and black swooshes. Below the logo, the company name 'SOMERSET INTERNATIONAL' is written in a bold, sans-serif font. Underneath the company name are two small images: one showing an industrial facility at night with lights on, labeled 'Process'; and another showing three cylindrical containers or tanks, labeled 'Results'.

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MINE XCHANGE

2025 SME ANNUAL CONFERENCE & EXPO

By the Numbers



- Total attendees: 7,037
- International registrants: 973
- Student registrants: 600
- Countries represented: 46
- Total exhibit booths: 827
- Total exhibitors: 601
- 250,000' exhibit hall - 82,700' exhibit space
- Total amount of awards given: 123
- Total number of technical sessions: 125
- World Gold technical sessions: 8
- Short course attendees: 243
- Short courses: 9



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MINEXCHANGE Recap



The wide range of technical sessions covered the latest research, technological advancements and best practices in mining.

While some feel that AI poses significant danger, Law said he sees a future that can be brighter, and a workplace that can be safer if AI is implemented the correct way. "We have to be the ones who are going to guide that process, and we need to make sure those models are built correctly, and we do that by being consumers of that technology," he said.

For health and safety specifically, Law said AI can be used for accident prevention through the detection of anomalies. He said health and safety professionals will be able to improve their ability to predict risks with AI because it can do the analysis quicker and better, which in turn will help create a risk matrix.

Spotlight on women in mining

The second day of MINEXCHANGE 2025 commenced on Feb. 25 with an inspiring gathering at the Women in SME Breakfast. The event was a celebration of achievements,

The Women in SME Breakfast was an inspiring celebration of achievements and tribute to pioneers.



a tribute to pioneers and a call to action for greater inclusivity within the sector, forming a backdrop for empowerment, reflection and progress for women in the mining industry.

The breakfast began with a video presentation from FLS, offering insight into its contributions to the mining industry. Among those featured was Margen Gerty, who spoke passionately about the company's mission and impact.

Allison Kopal, who opened the breakfast presentation, set the stage for a morning filled with heartfelt tributes and dynamic discussions. She introduced the Cindy Moore Courageous Impact Award, an honor dedicated to the late Cindy Moore, who battled amyotrophic lateral sclerosis (ALS). To ensure her legacy continues, Hecla Mining Co. established the award, recognizing individuals who embody resilience and positive influence. Joanne Robertson, this year's recipient, was soundly applauded for her contributions to the industry.

Next, the WAAIME Founders Award was presented to Zenovia Kunasz, whose inspiring journey was shared with the audience. Kunasz spoke about her upbringing, reflecting on how her parents endured hardships during the Soviet War. Upon receiving her award, she humbly stated that she shares the honor with everyone who has supported her journey.

A poignant moment followed with a tribute to the late Rebecca Bweupe-Siwale. Through a heartfelt speech given by Line-Audrey Nkule, who works for Caterpillar Inc. and was originally from Cameroon, the attendees honored Bweupe-Siwale's generosity, leadership and deep impact. Nkule, with tears in her eyes, described Bweupe-Siwale as a generous soul who was the "work mom" she needed. A memorial book was placed at a center table, located at the back of the room, for attendees to leave messages in Bweupe-Siwale's honor.

The breakfast also served as a platform to launch the Rebecca Bweupe-Siwale Memorial Scholarship Fund, aimed at supporting women in mining. Donations collected during the event will help provide scholarships to students, including Bweupe-Siwale's eldest daughter, who is excelling

academically while caring for her younger siblings.

The focus then shifted to the future, as discussions centered around empowering and retaining women in the mining workforce. Kopal engaged attendees in an interactive exercise, prompting them to describe in 12 words what needs to improve to retain more women in the industry. The responses — ranging from “connection” and “community” to “trust” and “mentorship” — highlighted critical areas for change.

Keynote speaker Sharon Saffold Harris took the stage with an eye-opening address on

the challenges and opportunities for women in mining. She began with a powerful question: “How many women have you referred to work in mining?” Attendees were encouraged to reflect and discuss with their neighbors.

Harris shared findings from a study she helped design, which included interviews with women in the field. One common response to the question of women’s visibility in mining was that women in the industry are often hidden. Harris emphasized the need to break this silence and actively support one another.

“Mining will get better when we all do better.

World Gold 2025 adds luster to MINEXCHANGE

A unique aspect of the MINEXCHANGE 2025 SME Annual Conference & Expo was the addition of the World Gold Conference (WGC) 2025. The decision to co-locate WGC with MINEXCHANGE provided attendees with enriched insights into the gold sector and allowed a unique platform for industry experts to delve into current trends, challenges and advancements within the gold mining industry.

WGC 2025 served as a platform for in-depth discussions on topics such as gold geology, green development, metallurgy, smart technologies, mine safety, deep mining and precious metals. With a strong technical program, attendees gained insights into the latest research and technological innovations in gold mining.

“I thought each of the seven sessions that we brought were very successful, and were well attended,” said organizing committee co-chair Nick Gow, senior study manager at Paterson & Cooke USA. “We broadly covered mining, geology, process, safety and new technologies.”

Presentations covered sustainable practices, new processing techniques and real-world case studies, fostering collaboration and knowledge sharing. The event also created opportunities for networking, enabling industry professionals to connect, exchange ideas and explore new partnerships.



The World Gold Reception was held at the Colorado School of Mines Museum of Earth Science in Golden, CO.

One highlight of WGC 2025’s presence at MINEXCHANGE was the World Gold Reception, held on Feb. 24 at the Colorado School of Mines Museum of Earth Science in Golden, CO. The reception served as an opportunity for participants to connect with industry professionals and discuss the latest trends in the gold sector. This event fostered collaboration among experts, researchers and stakeholders, enhancing the overall conference experience.

“The World Gold Reception was a good representation of the overall event,” said Gow. “There was significant interest in both the reception and the short course that was put on: Gold Processing Fundamentals, by Jaeheon Lee.”

By co-locating WGC 2025 with MINEXCHANGE, the conference facilitated a broader discussion on mining and metallurgy, incorporating diverse perspectives and expertise. The event emphasized the importance of innovation and sustainability in gold mining, addressing current challenges and identifying new opportunities for growth.

The next World Gold Conference will take place in Australia in 2027, as part of a five-society rotation between SME, the Southern African Institute of Mining and Metallurgy (SAIMM), Australasian Institute of Mining and Metallurgy (AusIMM), Canadian Institute of Mining, Metallurgy and Petroleum (CIM) and China Gold Association (CGA). ■

MINEXCHANGE Recap

Let's walk each other home," said Harris.

Her address touched on vital themes, including mentorship, marketing and the "double economy" women navigate — balancing professional and personal responsibilities. Harris urged the audience to take charge.

The breakfast concluded with an engaging Q&A session using Slido, sparking insightful table discussions on what companies, men and allies can do to improve retention and inclusion in mining. As Harris aptly put it, "Every woman in mining is tough," given the industry's current circumstances, but with strong networks, mentorship and company support, toughness

does not have to mean going it alone.

With the Women in SME Breakfast setting a high bar, MINEXCHANGE's second day continued with a renewed commitment to fostering a more inclusive and supportive industry. The message was clear: the future of mining will be stronger when women are empowered, valued and given the opportunities they deserve.

Robust technical programming

MINEXCHANGE featured robust technical programs throughout each day, encompassing a wide range of sessions that addressed the latest research, technological advancements and best

Colorado Mining Association awards luncheon ...

On day three of the MINEXCHANGE 2025 SME Annual Conference & Expo, National Mining Association (NMA) president and chief executive officer Rich Nolan joined Colorado Mining Association (CMA) president and chief executive officer Adam Eckman to discuss national mining trends, as well as public policy challenges and opportunities in Washington, DC that are taking place during a transformative time for the mining industry. They spoke during the CMA Reclamation and Safety Awards Luncheon on Feb. 26 during the CMA 127th National Western Mining Conference, held in conjunction with MINEXCHANGE 2025.

As President Donald Trump begins a second term, Nolan expressed optimism for the nation's mining industry while discussing a wide range of topics important to the industry including permitting reform, good Samaritan efforts for mine land reclamation, workforce and growing energy demand as well as the ongoing threat to national security because of China's global mineral dominance.

"There is a tremendous increase in awareness for the importance of mined materials," said Nolan. "We are witnessing some bipartisan support that we haven't seen in my lifetime, and we are entering the most mining-intensive era since World

War II and that is very exciting."

Eckman and Nolan discussed the growing energy demand from increased electric vehicles, data centers and artificial intelligence, and how a renewed interest in nuclear energy and uranium mining can help provide much-needed clean energy for the United States.

Speaking of what is driving increased interest in mining and mineral development, Nolan said, "Geopolitical demand, technology drivers and the concern about supply of what we will need, in addition to the fact that one of our greatest geopolitical rivals, China, has a 20-year head start and have really locked up a lot of resources. All of this has created a real sprint to take control of these assets so that we are not being dictated to by adversarial nations."

NMA has long promoted permitting reform for the United States. Nolan cited a study conducted by S&P Global that found that the average length of time it takes for a mine to move from discovery of the deposit to production in the United States is 29 years.

"There are a lot of reasons for that," said Nolan. "One reason that was pointed out is there is no longer a dedicated resource in the United



Colorado Senator John Hickenlooper addressed industry leaders and professionals during the luncheon via video chat.

States focused on mining, and there is a lack of coordination in Washington, DC."

Among the recent developments that could help propel the mining industry is the reintroduction of the Unearth Innovation Act — a bipartisan bill that would boost critical mineral innovation while helping the United States drive responsible domestic critical mineral production — which was reintroduced by Sens.

practices in mining. These topics included bulk material handling, environmental considerations, health and safety, mineral processing and exploration strategies, as well as gold-specific presentations. Each session provided valuable opportunities for professionals to deepen their knowledge and engage in meaningful discussions on critical industry issues.

From AI-driven fleet management to the revolutionary potential of 3D printing in mining, the conference provided valuable insights into how technology is shaping the future of the sector. Presenters from Riyadh, Saudi Arabia, explored the application of 3D printing in mining

during their presentation titled “3D printing in mining, A Use-Case,” highlighting its potential for on-demand spare part manufacturing. The ability to print parts directly on site offers operational efficiency but comes with challenges, including high production costs, material quality concerns and the need for specialized technical expertise. Despite these hurdles, this technology promises improved material quality and the ability to meet on-site demands swiftly.

A team from the Colorado School of Mines and McGill University discussed the design and implementation of AI-based fleet management systems in openpit mines in their presentation

... explores the national perspective of mining

John Hickenlooper and Thom Tillis on Feb. 13. Additionally, on Feb. 14, President Trump signed the Executive Order on “Establishing the National Energy Dominance Council (NEDC).” The NEDC is placed at a high level within the Executive Office of the President.

SME published a concept paper titled “Why the U.S. Needs a National Materials and Minerals Council” in July 2024 that proposed a similar organizational structure. While the SME concept paper is not cited in the Executive Order, the mission of the NEDC to coordinate the involvement of all of the cabinet-level executive branch departments is also similar to the organization described in the NMMC concept paper.

Following Nolan and Eckman’s discussion, Colorado Senator John Hickenlooper addressed industry leaders and professionals during the luncheon. Speaking via video chat, the senator emphasized the need to reevaluate the nation’s approach to mining and minerals, calling for a balanced framework that ensures profitability while upholding the highest environmental standards.

Hickenlooper highlighted that the world’s growing demand for critical minerals, including copper and nickel, is forging an unprecedented alignment between environmentalists and mining professionals. He

noted that ensuring a reliable domestic supply of these minerals is vital to economic security and climate initiatives.

The senator discussed permitting reform as a key issue, stressing the importance of transparency and public engagement in shaping responsible mining practices. Calling for a renewed focus on mineral mining, Hickenlooper urged the industry to ensure mining practices remain environmentally sustainable. In a world increasingly dependent on critical minerals for everything from renewable energy to defense technology, the senator emphasized that the industry must align with environmentalists to secure a future that benefits all stakeholders.

“This is a time to find new ways of American leadership, especially in mining,” said Hickenlooper. “And what we agree to and create for this country will set standards for the world.” He also underscored the role of nuclear energy as part of the transition to clean energy, acknowledging concerns over waste management but reaffirming its potential for high-quality, low-emission power generation.

The senator detailed legislative efforts aimed at securing the critical mineral supply chain. He pointed to the National Critical Minerals Council Act, which establishes an execu-

tive office to coordinate critical mineral activities, as well as the Future Act, which funds pilot programs exploring price support mechanisms to protect American mining interests. Hickenlooper also mentioned the Strategic Minerals Act, co-sponsored with Senator Todd Young.

Highlighting the international competition for mining expertise, Hickenlooper noted that while the United States currently has only 600 students enrolled in mining-related programs, China boasts 1.4 million. He stressed the urgent need to build a domestic workforce capable of meeting the industry’s challenges and called for initiatives akin to past national efforts, such as the Space Race, to drive mining education and innovation forward.

Hickenlooper concluded by stressing that this is a pivotal moment for American leadership in mining. He asserted that decisions made today will set global standards for sustainability and safety, reinforcing the importance of responsible mineral extraction in shaping the nation’s economic and environmental future. As MINEXCHANGE 2025 progressed, the senator’s message served as a rallying call for industry leaders to seize the opportunity to drive innovation and establish the United States as a leader in the global mining sector. ■

MINEXCHANGE Recap



Attendees thronged the SME Awards Celebration to honor some of the biggest names in the mining and minerals community.

titled “Design, development and implementation of operational fleet management systems using adaptive artificial intelligence techniques.” Traditional dispatch-based methods often yield suboptimal results, prompting the need for goal-weight rearrangement via AI frameworks. By applying adaptive intelligence, mining operations can enhance efficiency and optimize decision-making in fleet management.

In one of the World Gold-focused technical sessions, GeoGlobal LLC revisited distal disseminated gold-silver deposits in Nevada, emphasizing their exploration potential, in their presentation titled “Revisiting distal disseminated gold silver deposits in Nevada: opportunities for future exploration.” These deposits, often associated with polymetallic plutonic rocks and Carlin-type sediment-hosted formations, present new opportunities for resource extraction. The research focused on geological characteristics, mineralization controls, and the need for deeper exploration to unlock their full potential.

Another gold-focused session featured gold-rich asteroids and examined the economic and scientific implications of extraterrestrial mining. Researchers from Peru analyzed asteroid compositions, particularly Psyche 16, a metal-rich asteroid potentially containing vast amounts of gold, platinum and other precious metals, in their session titled “Analysis of the composition of gold-rich asteroids: Implications for space exploration and the global economy.” The National Aeronautics and Space Administration’s (NASA) Psyche Mission, launched in 2023, aims to study the asteroid’s structure and magnetic field, providing

insights into planetary ore formation. Despite the immense economic potential, challenges such as mining in low-gravity environments and ethical concerns regarding space resource ownership remain significant.

In addition to these technical sessions, Newmont’s mine control maturity assessment underscored the transition toward data-driven underground operations in their session titled “Mine control maturity assessment: Establishing the guidelines for underground operations to become data driven.” The

discussion highlighted key success factors, such as domain expertise, the integration of various data types and the necessity of framing the right questions. The session also addressed concerns about the misuse of AI tools, emphasizing the need for responsible implementation to avoid inaccurate risk assessments.

A novel approach to workforce improvement was also presented through the integration of the metaverse and AI in mining training, in the session titled “A Novel Approach to Workforce Improvement Using the MetaVerse Turning AI into IA (Intelligence Amplification).” The platform simulates realistic work environments, allowing employees to develop problem-solving skills through immersive experiences. Combining deep learning with AI-driven analytics, the system provides tailored assessments and adaptive learning paths. This innovation aims to amplify workforce intelligence and improve safety and efficiency in mining operations.

In addition to the technical sessions, attendees had the chance to participate in interactive workshops and short courses, further enhancing their professional development.

The expansive exhibit hall showcased the latest products, services and integrated solutions from leading industry vendors, offering a firsthand look at innovations designed to make mining operations smarter, safer and more efficient.

MINEXCHANGE 2025 served as a vital forum for professionals to exchange ideas, explore cutting-edge technologies and discuss sustainable mining solutions, reinforcing its role as a cornerstone event in the mining industry’s calendar. ■

The future meets the present at the MPD plenary session and luncheon

by Chee Theng, Managing Technical Editor

Life is a journey. And it is a journey that gets more than a little help from friends, family and colleagues, as evidenced during the Mineral & Metallurgical Processing Division (MPD) events at the MINEXCHANGE 2025 SME Annual Conference & Expo in Denver, CO.

Antoine M. Gaudin Award recipient Zhenghe Xu, Robert H. Richards Award recipient Jaisen Kohmuench and Milton E. Wadsworth Award recipient Michael Free thanked the many people in their lives in their award lectures at the MPD Plenary Session on Feb. 24, chaired by 2025 Program Chair Tarun Bhamhani. The session ended with a certificate presentation to Mohit Gupta for winning the Rong Yu Wan Ph.D. Dissertation Scholarship Award.

At the MPD Luncheon held Feb. 26 and hosted by MPD Chair Jaeheon Lee, the featured speaker Michael Blois was supported from the head table by his wife and daughter. Representing the future were Kathleen Troy, Chandima Subasinghe, Paubla Gallego and Ellah Olson, who were presented with their scholarship certificates, while Jordan Rutledge received the MPD Outstanding Young Engineer Award, and Naci Duru and Carl Nesbitt the Arthur F. Taggart Awards. Following tradition, MPD Past Chair David Meadows presented Lee with the Mill Gentleman of Distinction Award, which includes a personal poem about Lee's life written by Meadows and translated into Latin. ■



Michael Blois gets a round of applause as the MPD Luncheon featured speaker.



Reaching the top: Zhenghe Xu, Jaisen Kohmuench and Michael Free are the MPD Awards Lecturers.



The next generation: (left to right) MPD scholarship recipients Kathleen Troy, Chandima Subasinghe, Paubla Gallego and Ellah Olson.



Winners and friends (left to right): Courtney Young, Zhenghe Xu, Jaisen Kohmuench, Mohit Gupta, Tarun Bhamhani, Aaron Noble, Roe-Hoan Yoon.

How to get more involved in MINEXCHANGE 2026

Plan ahead to get the most out of your MINEXCHANGE 2026 SME Annual Conference & Expo experience, coming up in February in Salt Lake City, UT. Explore the full spectrum of activities that go beyond the session rooms and exhibit hall.

Are you interested in helping to organize the Coal & Energy Division or Mineral & Metallurgical Processing Division (MPD) technical programming of the next MINEXCHANGE? Attend the division's Unit Committee Meeting and volunteer to join or even chair one of the unit committees.

Are you a student with research work to share with the community? Submit an abstract for a chance to present a poster and win cool cash prizes at one of three (Environmental Division, Graduate and MPD) student poster sessions held during the conference. If you are an industry, government or academic professional, drop by to view the posters and to engage with and encourage the next generation of miners and metallurgists.

Give full rein to your competitive spirit and enter your bid to win enticing items, including rare mining memorabilia, at the silent auctions hosted by the SME Foundation and Divisions.

As each day draws to a close, head out to one or more of an exciting range of social events, from the always fun



The SME Foundation Gala is the perfect time to share fun and laughter and to celebrate achievements with friends.

SME Foundation Gala to the Young Leaders Monday Night Social to the alumni and WAAIME receptions and the not-to-be-missed Scotch Nightcap.

These are just a few of the many ways you can be more involved in your next MINEXCHANGE. Be on the lookout for more information in your SME Drift e-newsletter, emails and SME Community posts. ■



Aaron Noble welcomed nearly 100 volunteers at the MPD Unit Committee Meeting, all pysched to help plan MINEXCHANGE 2026.



Bidding for enticing items at the SME Foundation and Divisions auctions.

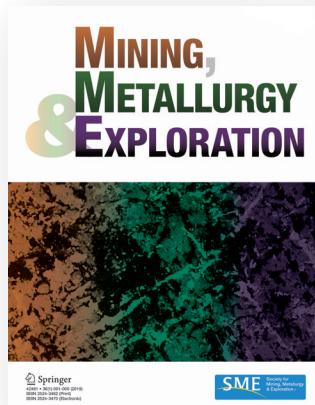


Triveni Gangadari walked away with \$1,000 by impressing judges at the MPD Student Poster Contest.



Rocking the night away with the Bass Metals band at the Scotch Nightcap on Tuesday night is a MINEXCHANGE badge of honor.

Extended abstracts from the SME journal Mining, Metallurgy & Exploration



Take full advantage of your SME membership. As a member, you can read and download for free all of the full-text papers in *Mining, Metallurgy & Exploration (MME)* and the archives of *Minerals & Metallurgical Processing (MMP)*. Log in to the SME website as a member, and enter the MME Springer website through our dedicated SME link:

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For assistance anytime, email Chee Theng at theng@smenet.org. ■



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Invited Extended Abstracts

Collection on Sustainable Development in the Minerals Industry

Synthesis and morphology of slag-based alkali-activated materials

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Full-text paper:

Mining, Metallurgy & Exploration (2025) 42:1–13, <https://doi.org/10.1007/s42461-024-01161-5>

Keywords: Ferronickel slag, Alkali-activation, Curing, Compressive strength, Microstructure, Construction materials

Large volumes of slags, with varying mineralogical and geochemical characteristics, are produced annually by the ferrous and nonferrous metallurgical industry. Most of them are considered as potential secondary resources and may be valorized, following the principles of circular economy, for the recovery of critical elements, including energy transition metals. Apart from the economic benefits, valorization of slags may contribute to the competitiveness of the metal industry and the conservation of natural resources. Valorization also results in minimization of environmental impacts on soils and waters in slag disposal areas, due to the prevention of solubi-

lization and subsequent migration of potentially hazardous elements. The present study utilizes ferronickel (FeNi) slag for the production of alkali-activated materials. The effects of the main experimental parameters, including sodium hydroxide (NaOH) molarity, silica/sodium oxide ($\text{SiO}_2/\text{Na}_2\text{O}$) molar ratio in the activating solution, precuring and curing time, curing temperature and aging period on several properties of the final products, are assessed.

Background

Alkali activation may be used for the valorization of

MME Technical-Paper Abstracts

several industrial wastes, including sludges, process tailings and slags. The produced materials are partially amorphous, have beneficial properties and may be used as construction elements or as binders to partially substitute Portland cement. They are termed alkali-activated materials (AAMs), geopolymers or inorganic polymers (IPs). Alkali activation involves the reaction of (calcium ferro-)aluminosilicate precursors with strong alkaline solutions for the production of a reactive paste. This paste after curing for a few hours or days at relatively low temperatures of 20 to 90 °C and aging for seven to 28 days enables the production of specimens with desirable physicochemical and mechanical properties. Depending on the byproduct (waste) type, the mineralogy and, more specifically, the composition of the amorphous phase (for example, Si/Al ratio or (Ca+Fe)/Si ratio), the grain size and the type of alkali activating solution, the synthesis conditions need to be optimized to produce the desired AAMs.

Methodology

The slag (LS) used in this study is a byproduct of FeNi

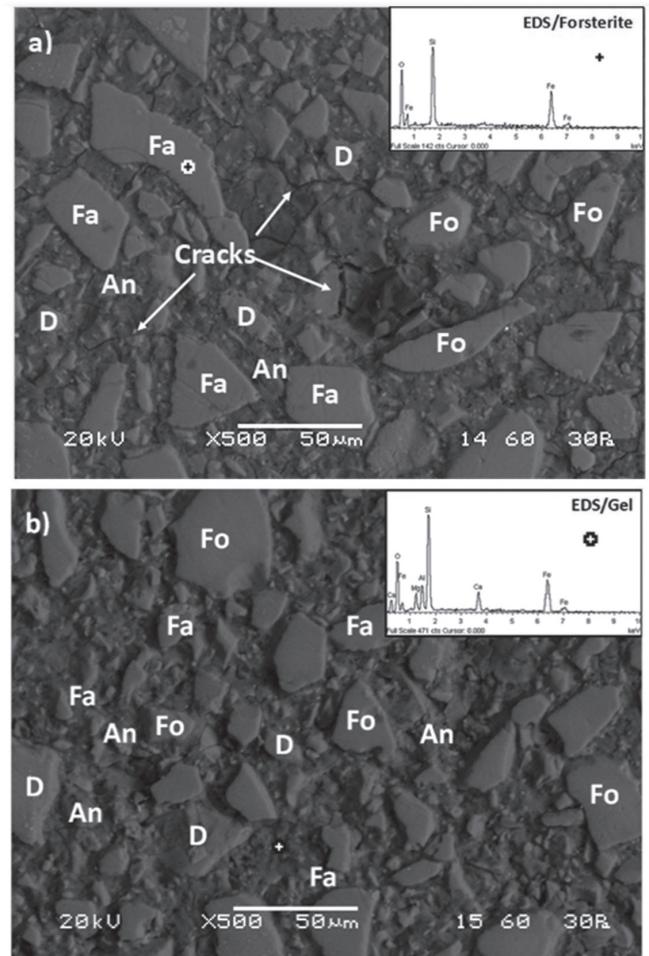


Fig. 2 Back-scattered electron images of cross-sections of selected AAMs produced after curing at (a) 20 °C and (b) 80 °C.

The operating conditions were NaOH molarity 8 M, $\text{SiO}_2/\text{Na}_2\text{O}$ molar ratio in solution 1, precuring and curing times 24 hours and aging period seven days. EDS spectra show in several spot locations the presence of oxides and the formation of reaction products (Fo: forsterite, D: diasporite, Fa: fayalite, An: anorthite).

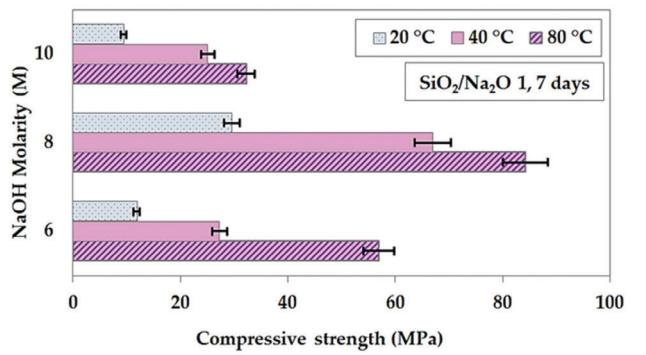


Fig. 1 Evolution of compressive strength of produced AAMs versus NaOH molarity as a function of curing temperature (20, 40 and 80 °C). Precuring and curing times = 24 hours. Error bars indicate the standard deviation of three measurements.

production from Greek laterites. Its chemical composition in the form of oxides, as well as the particle size of the ground slag, as indicated by the d_{90} and d_{50} percentile values, are shown in Table 1.

NaOH and sodium silicate (Na_2SiO_3) were used as activating solutions. For the synthesis of AAMs, LS was mixed slowly for 10 min with the activating solution and the produced homogeneous paste was cast in plastic cubic molds, with an edge of 5 cm. The molds were left at room temperature for 24 to 96 hours for precuring to enable initiation of

Table 1 – (a) Chemical analysis of the slag in the form of oxides (weight percent) and (b) particle size analysis.

(a) Oxide (weight percent)			
Fe_2O_3	39.6	Na_2O	0.6
SiO_2	33.1	K_2O	0.4
Al_2O_3	8.7	MnO	0.4
MgO	6.9	NiO	0.1
CaO	5.3	P_2O_5	0.03
Cr_2O_3	2.7	ZnO	0.01
SO_3	0.3	CoO	0.004
TiO_2	0.8	CuO	0.002
(b) Particle size of ground slag (μm)			
d_{90}	48.4	d_{50}	9.5

Table 2 – Experimental details and selected molar ratios in the activating solution.

NaOH (M)	Solids	NaOH	H_2O	Na_2SiO_3	Ratios		
	(weight percent)				L/S	$\text{H}_2\text{O}/\text{Na}_2\text{O}^*$	$\text{SiO}_2/\text{Na}_2\text{O}^*$
6	82.9	1.7	6.9	8.5	0.2	21.5	1.0
	81.6	2.3	6.9	9.2	0.2	17.4	1.0
8	80.3	2.7	8.1	8.9	0.3	16.8	0.8
	79.0	2.4	7.0	11.5	0.3	18.0	1.2
10	76.9	3.5	8.1	11.6	0.3	14.9	1.0

*Molar ratios in the activating solution.

alkali activation reactions and sufficient hardening of the obtained paste. The specimens were then placed in an oven for curing at 40 and 80 °C for 24 hours. Aging of all specimens was carried out at room temperature for seven, 28 or 96 days. Table 2 shows the experimental details of the tests carried out.

Several analytical characterization techniques, including X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS), were applied to study the characteristics of the raw material and the produced AAMs. The main parameters determined to assess the quality of the final products were compressive strength, density, porosity and water absorption.

Results and discussion

Figure 1 presents the evolution of the compressive strength of the produced AAMs versus NaOH molarity (6 to 10 M) as a function of curing temperature (20, 40 and 80 °C). It is seen that increasing the curing temperature from 20 to 80 °C substantially improves the compressive strength of the produced AAMs for all molarities tested. The optimum NaOH molarity is 8 M, while the maximum compressive strength obtained after curing at 80 °C for an aging period of seven days is 84 MPa.

SEM back-scattered electron (BSE) images of selected AAMs are shown in Fig. 2. More specifically, SEM/EDS microscopic examination of AAMs produced after curing at 20

°C revealed the presence of several microcracks (smaller than 10 µm) in the polymeric matrix as well as a heterogeneous and porous structure with large unreacted/undissolved slag particles (larger than 20 µm) exhibiting sharp edges (Fig. 2a). On the other hand, the microstructure of the LS-based AAMs produced after curing at 80 °C exhibits a glassy and smooth surface with no visible cracks and defects (Fig. 2b).

Conclusion

Ferronickel slags can be successfully alkali activated. The maximum compressive strength of the produced AAMs exceeds 80 MPa. The valorization of metallurgical slags for the production of AAMs, apart from the obvious environmental benefits, is also in line with various United Nations Sustainable Development Goals (SDGs), including SDGs 11, 12 and 13. ■

Funding

The study received funding in the frame of ENICON project, “Sustainable processing of Europe’s low grade sulphidic and lateritic Ni/Co ores and tailings into battery grade metals,” <https://enicon-horizon.eu/>, from the European Union’s Framework Programme for Research and Innovation Horizon Europe under Grant Agreement No. 101058124.

References

A list of all references is available in the full paper.

Analyzing battery swapping of battery-electric load haul dump (LHD) machines in block cave mining using discrete event simulation (DES)

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Keywords: Battery LHDs, Load haul dump, Block cave, Discrete event simulation, Swapping, Alternative hauling, Loop hauling, Queueing

Transitioning from diesel-powered loading and hauling machinery to battery-electric vehicles (BEVs) responds to the need for deepening underground mines as regulations become tighter. When using BEVs, exhaust gases and diesel particulate matter (DPM) emissions can be eliminated, and the energy required for the machines is used more effectively. Unlike their diesel counterparts, which are refueled, BEV loading and hauling machines—specifically, load haul dump (LHD) machines—can use battery swapping. This brings additional aspects to the operation that need to be considered, which have not yet been studied extensively. This study used discrete event simulation (DES) to analyze how the different numbers of BEV LHDs affect queueing and productivity when using different numbers of batteries and different swapping

times in an underground block cave mine. The results identified the formation of working groups, where the machines swapped their batteries concurrently within each group, and their relation to the queueing time. Additionally, the minimum number of batteries per machine was identified to maximize productivity while minimizing queueing time. This study demonstrates DES as a powerful tool to assess and analyze conceptual systems and identify their underlying structures, which can enhance the deployment of BEV LHDs in underground block cave mine operations.

Background

Loading and hauling operations conducted with LHDs are a central part of underground mining operations. As

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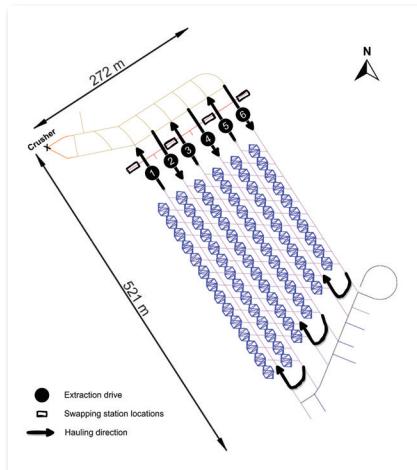


Fig. 1 Simulated layout with swapping station locations and LHD hauling directions.

underground mining moves deeper, mines are facing more challenges in providing a healthy working environment for miners, as well as sustaining cost-effective operations because of ventilation requirements. Currently, several original equipment manufacturers (OEMs) provide LHDs powered primarily by three different power sources: diesel, electric (cable-tethered) and BEVs. Electric vehicles and BEVs do not emit exhaust gases or DPM. In terms of operation, diesel and BEV LHDs enable similarly flexible operations from the movement perspective, while the electric version can face logistical issues and limitations due to the trailing cable. To date, research on the operational aspects of underground mining LHDs has mainly focused on electric and diesel LHDs. Therefore, this study was initiated to analyze and evaluate how different numbers of BEV LHDs and different battery swapping times in underground block cave mine affect the efficiency of the machines when varying the number of available batteries.

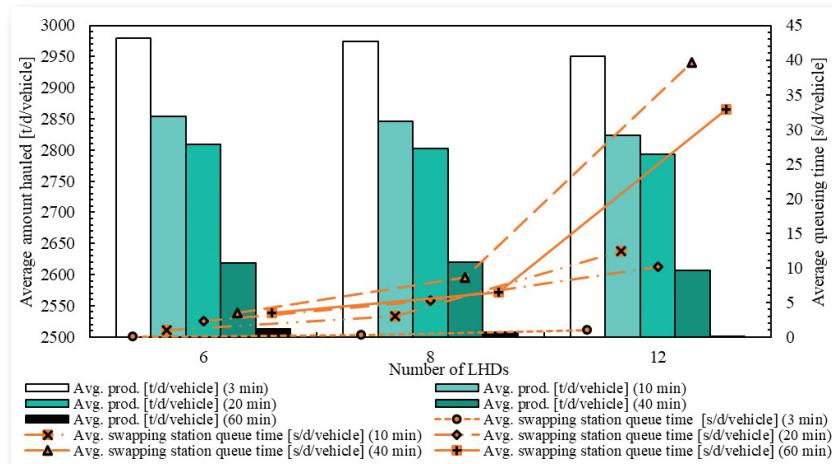


Fig. 2 Average daily amount hauled and queueing time for swapping station per LHD with 80 percent availability, using an unlimited number of batteries and swap times of 3, 10, 20, 40 and 60 min.

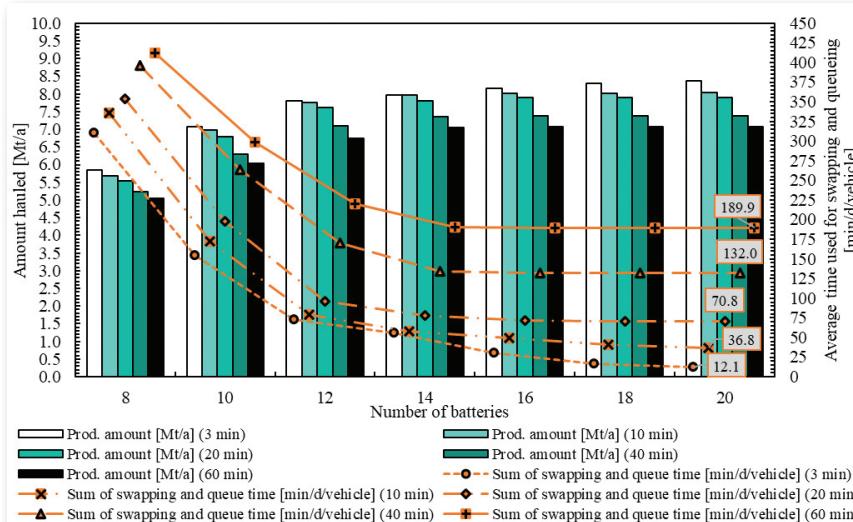


Fig. 3 Yearly amount hauled and the sum of swapping and queueing time for an available battery per LHD with 80 percent availability, using a limited number of batteries and swap times of 3, 10, 20, 40 and 60 min.

Methodology

A DES model was built with Arena using a feasibility-study-stage layout of an underground block cave mine (Fig. 1). The layout consists of six extraction drives, where each drive has its battery swapping station. The loading and hauling operations are conducted using LHDs that operate in a circulative pattern, forming a clockwise loop between the drives (6-5, 4-3 and 2-1 when the exiting drive is available; otherwise, the LHD will perform a counterclockwise loop) and the crusher.

In previous studies, it was found that a minimum number of eight LHDs was required to reach the set production target. To assess the effect of different numbers of LHDs on queueing, six and 12 LHDs were additionally simulated with different swapping times (the time it takes for a battery to be swapped). Simulations were initiated using an unlimited number of batteries with these three numbers of LHDs and five different battery swap times (Table 1) to identify the amount of time the LHDs spent queueing because another machine is already occupying the battery swapping station — as the LHD needs to wait until the LHD ahead of it has conducted its battery swap — and whether this amount increases as the number of LHDs increases or as the battery swap time changes.

Subsequently, the simulations were continued using a limited number of batteries between eight and 20, with eight LHDs using the same five different battery swap times (Table 2). This was conducted to determine the amount of queueing due to a lack of batteries and how queueing and productivity were affected when using different battery swap times, and to identify the required number of batteries.

Results and discussion

According to the simulation results,

Table 1 – Simulation scenarios for an unlimited number of batteries with 6, 8 and 12 LHDs.

(a) Scenario	No. of LHDs	Battery swap time (min)
1.1-1.5	6	3, 10, 20, 40, 60
2.1-2.5	8	3, 10, 20, 40, 60
3.1-3.5	12	3, 10, 20, 40, 60

Table 2 – Simulation scenarios for a limited number of batteries with 8 LHDs.

(b) Scenario	No. of batteries (pieces)	Battery swap time (min)
4.1-4.5	8	3, 10, 20, 40, 60
5.1-5.5	10	3, 10, 20, 40, 60
6.1-6.5	12	3, 10, 20, 40, 60
7.1-7.5	14	3, 10, 20, 40, 60
8.1-8.5	16	3, 10, 20, 40, 60
9.1-9.5	18	3, 10, 20, 40, 60
10.1-10.5	20	3, 10, 20, 40, 60

when using an unlimited number of batteries, even with a maximum number of 12 LHDs and a maximum duration of 60 min swap time, the queueing time will be very low: 40 s per day per LHD (Fig. 2). During these simulations, it was noted that when having four battery swap stations and a maximum of 12 LHDs, the queueing time will stay low as long as the number of working groups stays lower than the ratio of the operational time of the battery to battery swap time, when there are enough batteries within the system. A simplified explanation of the formation of these working groups is presented in Table 3.

Results simulated using a limited number of batteries suggest that with 16 to 18 batteries, depending on the battery swap time, the eight LHDs reach the minimum queueing time and the maximum productivity (Fig. 3).

The minimum queueing is reached as the average time used for swapping and queueing reduces close to the time that the machines used only for swapping when queueing is excluded (that is, the average time used for swapping when using an unlimited number of batteries — see Fig. 6 in the full paper).

Conclusions

In this study, the operational aspects of BEV LHDs with battery swapping were analyzed. A DES was used in a conceptual study to assess how battery swapping affects the overall efficiency and whether it introduces additional bottlenecks to the operation in the form of queueing.

The results show that for this case with a feasibility-study-stage layout, when using four battery swapping stations, the accumulation of queueing was not observed even with 12 LHDs. During the simulations, the formation of the working groups was identified, and because the ratio of the

Table 3 – A simplified example of the formation of working groups.

Time (h)	6 LHDs	8 LHDs	12 LHDs
0	All LHDs start to work	All LHDs start to work	All LHDs start to work
4	4 LHDs start to swap batteries, 2 LHDs start to queue	4 LHDs start to swap batteries, 4 LHDs start to queue	4 LHDs start to swap batteries, 8 LHDs start to queue
5	4 LHDs back to work, 2 LHDs start to swap batteries	4 LHDs back to work, 4 LHDs start to swap batteries	4 LHDs back to work, 4 LHDs start to swap batteries, 4 LHDs continue to queue
6	4 LHDs have worked 1h, 2 LHDs return to work	4 LHDs have worked 1h, 4 LHDs return to work	4 LHDs have worked 1h, 4 LHDs return to work, 4 LHDs start to swap batteries
7	4 LHDs have worked 2h, 2 LHDs have worked 1h	4 LHDs have worked 2h, 4 LHDs have worked 1h	4 LHDs have worked 2h, 4 LHDs have worked 1h, 4 LHDs return to work
9	4 LHDs have worked 4h → start to swap batteries, 2 LHDs have worked 3h	4 LHDs have worked 4h → start to swap batteries, 4 LHDs have worked 3h	4 LHDs have worked 4h → start to swap batteries, 4 LHDs have worked 3h, 4 LHDs have worked 2h
10	4 LHDs return to work, 2 LHDs have worked 4h → start to swap batteries	4 LHDs return to work, 4 LHDs have worked 4h → start to swap batteries	4 LHDs return to work, 4 LHDs have worked 4h → start to swap batteries, 4 LHDs have worked 3h

operational time of the battery to the battery swapping time remained higher than the number of working groups (where working groups are the result of the ratio of the number of LHDs to number of battery swapping stations), as long as they had enough batteries to enable the required productivity, the amount of queueing remained low. ■

References

A list of all references is available in the full paper.

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Collection on Intelligent Mining

New approach on the development of operational fleet management systems using adaptative AI techniques: Analysis of adaptative goal weights

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Keywords: Fleet management systems, Operations research, Machine learning, Mine planning

Truck-shovel dispatch systems based on linear or nonlinear programming algorithms have been in operation since the mid-1980s, with different levels of success depending on the correct arrangement of operational resources and the complexity of the mine. These systems are known for shortcomings related to the logic behind the decision-making of the operational objectives. This makes it necessary to have a human agent (dispatcher) to guide the system when the operational parameters change, creating the possibility of suboptimal decisions due to the human factor. To address this issue, the present work discusses the implementation of a methodology based on artificial intelligence (AI) techniques to assist in the decision-making of the best optimization goals arrangement when operating a fleet management system. The focus of the analysis is on the evaluation of variable goal weights in a non-preemptive, multigoal optimization model for multiple uncertain scenarios based on regions of optimal feasibility.

Background

A fleet management system is a centralized structure that receives real-time information from each element that composes the fleet and transfers it into a schematic environment that represents the pit geometry. To this framework is added any possible destination (such as crushers, ore stockpiles and waste dumps) to create a virtual space where all

dispatch items are on display and from which the mathematical model can extract information to solve the truck allocation problem, or any other calculation required by the user. Depending on the expertise of the dispatcher and the complexity of the mine, the dispatch system can range from a simple display and truck assignment tool with intensive dispatcher work to an open self-optimizer truck allocator that requires minimum involvement of the dispatch operator.

However, a dispatch system is not able to conduct a flawless operation by itself for long. Because the system works based on snapshots of the mine at a given moment (available sources and destinations, truck current assignment and location, available paths, and other technical and environmental conditions) and runs whenever there is any change in one (or more) of the operational parameters in the field, the system must also be updated in accordance. If the operational parameters are not updated and do not reflect reality, solutions are still being computed but will include a factor of error with a fast-increasing rate as the optimization algorithm is not run every time a truck requires a new assignment. This results in undesired outcomes such as idled and over-trucked shovels simultaneously, traffic lines, unnecessary rerouting in travel paths (sometimes because truck operators ignore dispatch decisions) and ultimately, overflow of arbitrary destinations.

Adaptative AI methodology

The proposed methodology consists in a multioption strategic analysis of discrete events happening during a dispatching operation, in which multiple possible solution schemes could have been selected for the same purpose (variations in the formulation) so that a global optimum solution can be found. This is accomplished by evaluating the variable importance of each goal in a multigoal optimization model, and how each goal is sensitive to the operational parameters under scenarios of uncertainty. By that, it allows the interpretation of how each potential event, or the occurrence of multiple of them at the

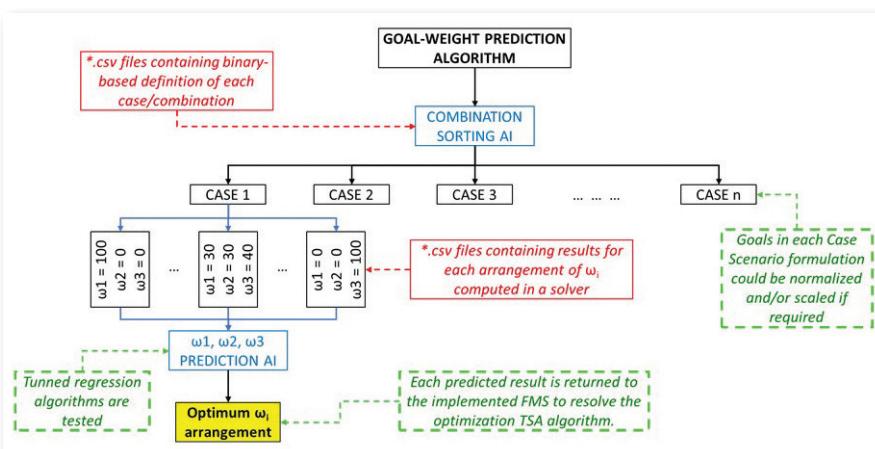


Fig. 1 Information flowchart for the goal weight/priority rearrangement approach.

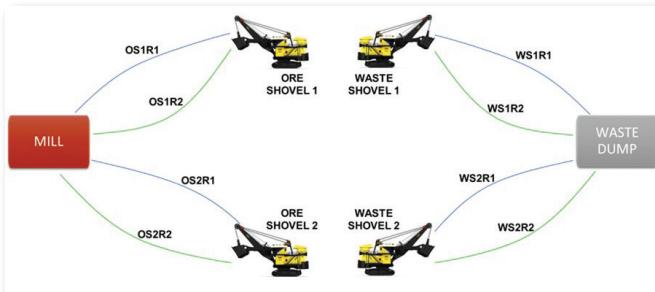


Fig. 2 Case study schematic distribution of sources, destinations and transportation paths.

same time, will impact the completion of the real-time targets, and whether a specific objective should be prioritized or preferred over the others while considering all possible tradeoffs. In Fig. 1, we can observe the flowchart of information of how the data is processed through two prediction algorithms, where the system first evaluates the exact conditions of the mine from a case-based scenario list, and then computes a set of possible goal weight arrangements to obtain the best possible outcome.

Case study and results

The methodology is tested in a simplified openpit mine environment (Fig. 2), where shovels have fixed tasks, limited destinations, and multiple roads to use. The disruption conditions evaluated for the analysis are composed of six possible events related to unavailable shovels, blocked roads and lack of trucks, under 64 combinatorial scenarios. The occurrence of each event is represented by binary values, with 1 as occurrence and 0 as nonoccurrence.

The optimization model evaluates a nonpreemptive, multigoal objective function:

$$\text{Min } Z = \sum_{p=1}^P (\omega_1^p \times \text{Ore Penalty}^p + \omega_2^p \times \text{Waste Penalty}^p + \omega_3^p \times \text{Transp Cost}^p) \quad (1)$$

aiming to minimize (1) penalties on ore production slack, (2) penalties on waste stripping slack and (3) overall transportation cost. The following defines the balance of goal weights such that the sum of all weights must be equal to 1.0 or 100 percent:

$$\sum_{i=1}^n \omega_i = 1.0 \quad (2)$$

From Eq. (1), ω_1^p corresponds to the assigned weight for ore production priority, ω_2^p is the assigned weight for waste stripping priority, and ω_3^p evaluates the assigned weight for transportation cost priority.

The results from the optimization of each combinatorial scenario are then adjusted to the proposed methodology, with the values of ω_i^p converted to cartesian coordinates, interpolated and displayed in ternary plots. The contours color spectrum represents the deviation of each

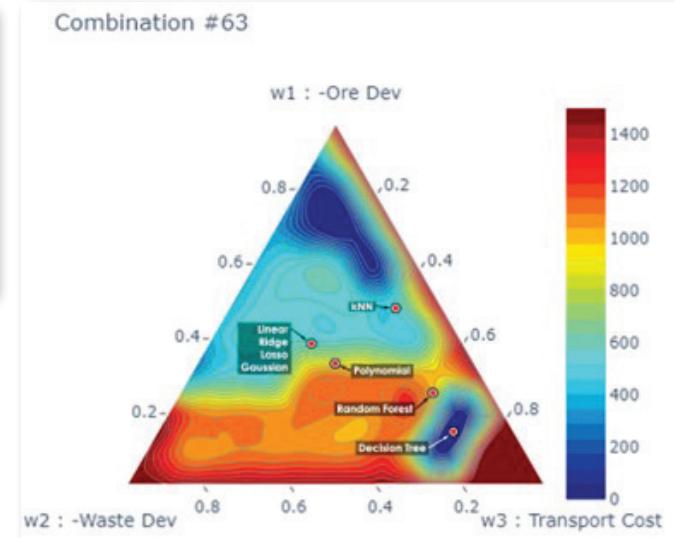


Fig. 3 Ternary plot displaying feasibility regions for combination #63. Predicted points on display.

goal-weight-adjusted solution with respect to best possible outcome, from blue (best) to red (worst). The model then evaluates eight machine learning regression models (linear, kNN, decision tree, ridge, lasso, random forest, gaussian and polynomial) in the prediction step, identifying a flawless outcome only for the decision tree algorithm in all evaluated scenarios. An example for one complex scenario is shown in Fig. 3, where multiple shovels, trucks and roads are affected.

With the selected regression model, the goal weight/priority rearrangement approach is now integrated into the proposed methodology, and all the predicted goal weights are re-solved in the optimization solver. This additional step is critical in the implementation logic as it is required to prove that the new goal weights are indeed returning the global optimal solution. In Table 1, the results for some combinations are displayed, confirming the mathematical correctness of the combined predictive model in the proposed methodology.

Table 1 – Comparison table of the overall costs between tested versus predicted weights for each goal.

Input	Predicted combination	Predicted values			Global optimum total cost (\$)		Accuracy (percent)
		ω_1	ω_2	ω_3	Calculated	Predicted	
[0 0 0 0 0 0]	1	34.00	34.00	32.00	52,440.00	52,440.00	100
[0 1 0 1 0 0]	14	23.64	54.09	22.27	71,710.00	71,710.00	100
[0 0 1 0 1 0]	18	20.00	10.00	70.00	213,180.00	213,180.00	100
[0 0 0 1 0 1]	21	35.00	43.75	21.25	82,855.00	82,855.00	100
[1 0 1 0 0 1]	28	45.00	38.33	16.67	149,095.00	149,095.00	100
[0 1 1 0 0 1]	35	39.33	37.33	23.33	131,665.00	131,665.00	100
[0 0 1 1 0 1]	40	41.11	33.33	25.56	144,445.00	144,445.00	100
[0 0 0 1 1 1]	42	15.00	15.00	70.00	149,160.00	149,160.00	100
[1 1 0 1 1 0]	46	30.00	12.50	57.50	148,920.00	148,920.00	100
[0 1 1 1 0 1]	54	41.11	33.33	25.56	164,470.00	164,470.00	100
[0 1 1 1 1 1]	63	15.00	15.00	70.00	214,800.00	214,800.00	100

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The implementation of the model confirms the adaptability of the methodology, as none of the parameters in any of the machine-learning-related steps were fixed, and all the input information was obtained from the implemented dispatch algorithm. Therefore, this methodology could be theoretically able to perform similar results in other types of data sets, regardless of the complexity of the operation and the type of prediction required.

Conclusions

A close inspection of the current implementation of a fleet management system shows that many components of the system are not properly integrated, and the system itself

has some severe restrictions in terms of self-management and analysis of high-variability operational parameters. The proposed methodology represents an opportunity to tackle these undesired conditions while enhancing the capabilities of the installed system. The different strategies described in this paper account for the most common scenarios that often require an interdisciplinary level of analysis, providing a realistic opportunity for the dispatch controller to compare their own decisions with suggested actions based on historical data, parametric analysis and predicted outcomes. ■

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A list of all references is available in the full paper.

Assessment of submicrometer-sized particles with practical activities in an underground coal mine

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Keywords: Miner exposure, RCMD, Respirable particles, Sampling technique

This study highlights the significant presence of submicrometer-sized airborne particles in underground coal mines, especially around the belt conveyor drift areas. Using real-time instruments and gravimetric samplers, the assessment revealed that particle concentrations were notably higher in the belt entry compared to other locations, with a strong presence of submicrometer- and nanoparticle-sized dust. The study's findings emphasize the importance of addressing small particle exposure, as these particles, composed of harmful substances like calcium, copper and iron, can pose serious health risks to miners. This research emphasizes the importance of improving air exposure estimation through more effective monitoring and characterization techniques to better understand and reduce workers' exposure to hazardous airborne particles in the mining environments.

Background

Submicrometer- and nanometer-sized particles in the coal mining environment represent a potentially serious but largely unstudied exposure risk. While modern mining equipment boosts productivity, it also generates more dust, including fine particles, especially those containing quartz (crystalline silica) that are associated with serious pulmonary diseases. Traditional devices like the Mine Safety and Health Administration (MSHA)-approved personal dust monitor cannot differentiate these small particles, and the mass-based monitoring methods are limited in capturing the contribution of small particles to the respirable coal mine dust (RCMD). Hence, this field study aims to evaluate respirable particles in the submicrometer to nanometer range using the newly designed Tsai diffusion sampler (TDS), along-

side other sampling and measurement techniques, to better understand their impact.

Methods

The mine dust exposure at a U.S. underground coal mine was monitored using real-time instruments and samplers across various areas, including the office building, underground entry, belt entry and belt conveyor drift, representing different work tasks.

Direct-reading, real-time measurements. Real-time instruments include a TSI NanoScan SMPS 3910 scanning mobility particle spectrometer, TSI OPS 3330 optical particle sizer and Thermo Fisher Scientific PDM3700 personal dust monitor. Real-time total dust number concentrations in particle counts were retrieved and averaged to present the particle levels in the underground coal mine areas. The office building, underground entry and belt entry work environments were measured using the SMPS and OPS to assess particle concentrations. The researchers wore the PDM to measure the personal, respirable-sized particle mass concentrations during the entire monitoring period.

Gravimetric filter sampling and novel TDS sampler. Airborne mine particles were collected using three different samplers — (1) an inhalable particle sampler: a 37-mm cassette with a polyvinyl chloride (PVC) filter according to the National Institute for Occupational Health and Safety (NIOSH) Manual Analytical Method (NMAM) 0500 sampling method, (2) a respirable dust cyclone: a 10-mm nylon cyclone with 37-mm Zefon cassette and PVC filter approved

by MSHA and (3) a 25-mm TDS with polycarbonate filter (0.22- μm pores) — and a transmission electron microscope (TEM) grid. Particle collection included area samples from the office building, belt entry and belt conveyor drift, as well as two personal samples from the researchers for breathing zone sampling.

Image analysis. The particles collected on the grids in TDS were analyzed by TEM at 200 kV using a Jeol JEM-2100F field emission electron microscope. The particles collected on the polycarbonate filter in the TDS and the PVC filter in the 37-mm cassette were examined by scanning electron microscopy (SEM) at 15 kV using the Jeol microscope. Additionally, the elemental composition of the TEM grid samples was analyzed by energy dispersive spectroscopy (EDS) on the TEM.

Results and discussion

Mine dust particles exposure level measured with direct-reading, real-time instruments. NanoScan SMPS measurements of 10 to 420 nanometer-sized particles showed much higher submicrometer particle concentrations in the belt entry ($34,700 \pm 56,300$ particles/cm 3) compared to the underground entry ($4,180 \pm 12,300$ particles/cm 3) and office building ($4,630 \pm 3,830$ particles/cm 3). OPS data of 0.3 to 10 micrometer-sized particles similarly showed higher concentrations in the belt entry ($167,000 \pm 57,700$ particles/cm 3) than in the office building ($10,180 \pm 1,960$ particles/cm 3) and underground entry ($16,100 \pm 4,760$ particles/cm 3) (Fig. 1). In the belt area, peak concentrations occurred at around 80 min, primarily due to dust resuspended by vibrations from the conveyor belt for transporting coal products. Peak-to-nonpeak concentration differences showed that the coal conveyor generates high levels of submicrometer particles, and they were suspended in the air longer than larger particles. The size fraction results clearly showed that the belt entry exhibited the highest concentration across micrometer- to submicrometer-sized (0.3 to 3.3 μm) and nanometer-sized (36.5 to 205.4 nm) particles compared to the office building and underground entry. PDMs and gravimetric samplers monitored the personal dust exposure in mass concentration. The average PDM mass concentration in the belt conveyor drift area was 0.18 ± 0.02 mg/m 3 . During coal haulage, it increased to 0.20 mg/m 3 and reached 0.22 mg/m 3 by the end of PDM sampling.

Mine dust particle exposure levels evaluated with gravimetric sampling. The measured mass concentrations clearly showed that more mine dust was collected in the belt conveyor drift area than other areas. The inhalable particle sampler following the NMAM 0500 sampling method found that the belt conveyor drift area has the highest respirable particle level (5.18 mg/m 3), followed by the belt entry (0.12 mg/m 3) and then the office building (0.02 mg/

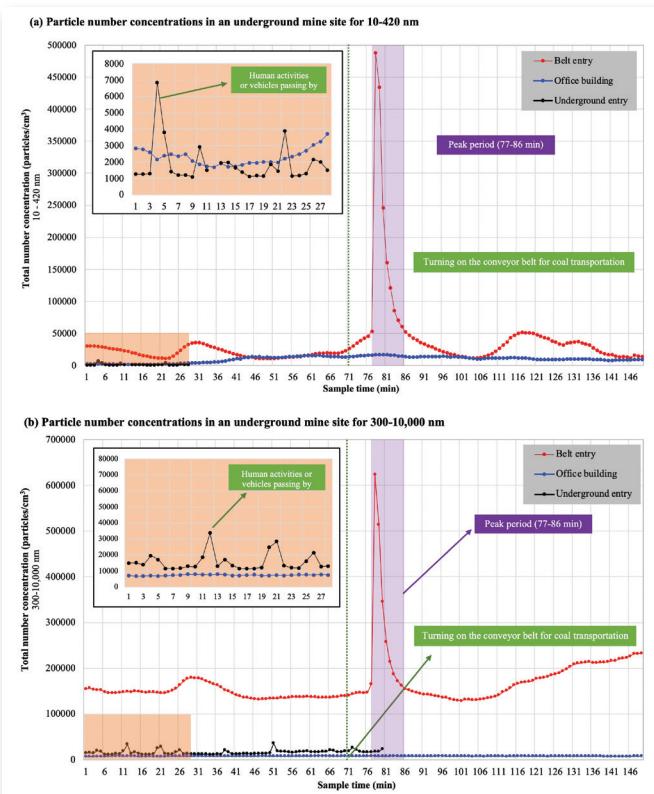


Fig. 1 Area particle sampling in an underground mine site on the office building, underground entry and belt entry by (a) NanoScan SMPS and (b) OPS.

m 3). The respirable cyclone samplers also found the same difference. Collecting particles in the nanometer and respirable size range, the TDS sampler results supported the finding that the highest respirable particle exposure was in the belt conveyor drift area (1.23 mg/m 3). Mass concentrations from samplers were compared to the American Conference of Governmental Industrial Hygienists (ACGIH) threshold

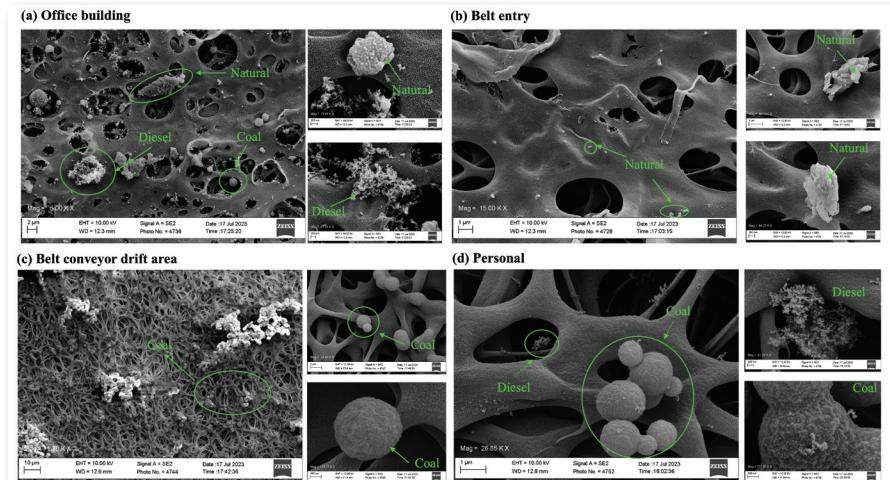


Fig. 2 Electron microscope images of dust particles sampled by inhalable particle sampler (37-mm cassette with PVC filter) (NIOSH 0500 method) at the underground mine present the particulate morphology in multiple locations by SEM: (a) office building, (b) belt entry, (c) belt conveyor drift area and (d) personal at belt conveyor drift area.

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limit value (TLV) of 0.90 mg/m³ and MSHA's permissible exposure limit (PEL) of 1.50 mg/m³ for respirable coal dust. Although our results were not based on an eight-hour TLV-time-weighted average (TWA), dust exposure levels in the belt area remain concerning, with heightened risks for workers walking behind others, requiring closer attention to potential elevated exposure.

Morphology and composition characteristics of particles. The surface features and morphology of the dust particles collected by the samplers were analyzed by electron microscopy (Fig. 2). The SEM images show varying particle morphology across sampling locations. In the office building, particles were relatively big (larger than 2 μm), mainly consisting of coal and diesel exhaust, indicating contamination from mine dust. In the belt conveyor drift area, mine dust particles agglomerated into solid spherical shapes, ranging from 400 nm to 1 μm in size. In contrast, personal samples showed looser, fiber-shaped particles finer than 200 nm. Diesel exhaust particles were also observed in the personal samples. The S/TEM with EDS spectrum confirmed that

particles in the office building likely originated from natural sources. The elements found in the area and personal samples at the belt conveyor drift area were comparable, mostly consisting of carbon (C) and copper (Cu). Particles found in the personal samples carry more metal elements, including platinum (Pt), cobalt (Co), magnesium (Mg), sodium (Na) and nickel (Ni), many of which are toxic, leading to a potential risk of adverse respiratory effect.

Conclusions

This field study concludes that RCMD remains a concern despite existing controls in underground mines. It highlights that submicrometer-sized particles are often underestimated by mass-based measurements. Protecting miners from exposure to these small particles is crucial to reduce the prevalence of coal workers' pneumoconiosis. Our study provides pioneering data using advanced sampling devices, offering a method for future particle exposure evaluations. ■

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A list of all references is available on the full paper.

Selected Abstract

Citric acid leaching performance at high solid-to-liquid ratios for lithium-ion battery recycling

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Full-text paper:

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Keywords: Hydrometallurgy, Lithium-ion batteries, Recycling, Leaching, Citric acid

This study investigated the performance of citric acid as lixiviant for cathode material from end-of-life lithium-ion batteries (LIBs). Black mass containing 84.2 weight percent MNC ($LiNi_{0.45}Mn_{0.4}Co_{0.15}O_2$) and 15.8 weight percent LCO ($LiCoO_2$) material was leached at solid-to-liquid ratios of 20, 50 and 100 g/L. Leaching with 1.5 M citric acid, 2 volume percent H_2O_2 and a solid-to-liquid ratio of 20 g/L at 95 °C extracted 90 percent Co, 95 percent Li, 94 percent Mn and 94 percent Ni within 20 min. At the highest solid-to-liquid ratio of 100 g/L with 1.5 M citric acid, 10 volume percent H_2O_2 and 95 °C, 84 percent Al, 84 percent Co, 87 percent Li, 86 percent Mn and 96 percent Ni were leached after 40 min, producing a leach solution containing 0.68 g/L Al, 20.0 g/L Co, 6.0 g/L Li, 13.6 g/L Mn and 19.3 g/L Ni. Using stepwise addition of H_2O_2 ,

instead of initial bulk addition, did not significantly improve the leaching efficiency but did reduce the required leaching time. Temperature control of the reactor was also more manageable with stepwise addition of H_2O_2 and evolution of gas was less vigorous. It was observed that the leaching efficiencies of Co, Li and Mn decreased slightly at solid-to-liquid ratios of 50 and 100 g/L, while the leaching of Ni increased slightly. The solution leached at 20 g/L could be stored for six weeks without any spontaneous precipitation. However, solutions leached at 50 and 100 g/L showed changes in concentration after one month of storage, suggesting that processes that have a large material throughput and use high solid-to-liquid ratios around 100 g/L must ensure that the solutions are not stored for extended periods of time. ■

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Warmer weather brings new challenges to mine sites; Tips for maintaining a safe workplace

by Matthew Main, Health & Safety Division Communications Chair

As winter's chill retreats and spring brings warmer days, seasonal mines that were shut down for the cold months start revving up for the busy season. Meanwhile, operating mines undergo a significant shift in their work environment, transitioning from winter to summer operations. These periods of change are critical times to ensure safety processes are followed to protect the well-being of all mine workers. This safety share aims to highlight the importance and potential hazards of these transitions and how to mitigate them.

Intermittent mines are the engine to the warm weather boost in construction projects that we see throughout the country. The term "making hay" not only applies to the agricultural industry, but it applies to us also as the suppliers of materials that drive our economy. For many year-round operations, "making hay" is the time when we see seasonal projects kick off that are best done during the summer months; and this means an increase in the number of contractors that we see on our sites. The warmer months bring great opportunity as well as increased challenges. Below are a few key reminders for our industry during the warm season.

After a long period of inactivity, mining equipment may face issues such as rust, mechanical failures and malfunctions. Thorough inspection and maintenance are paramount. Mine operators need to be sure equipment is in good working order before putting it into service. Be sure to include the miners that are on the front line, as they have insight that is invaluable to a safe, productive operation. Contractors will face the same challenge, and we need to ensure that contractor's equipment meets the standards required before allowing it to be used on the mine site. Once equipment is determined ready to be put into service,

establish a routine for equipment maintenance to ensure everything runs smoothly. Routine and preventive maintenance is planned work, and planned work means that we can assess risk and implement effective critical controls to prevent fatal or potentially fatal events.

Mines left dormant might experience structural weaknesses. Regular inspections for ground movement, loose rocks, and stability checks are essential. For mining operations that have continued to produce through the winter, consider how the changing conditions are impacting the ground stability. Spring runoff and thawing ground conditions can contradict our assumptions that we have had for the past several months.

Changes that we may have made due to temperature fluctuations may have to be changed again. Air pressures change with the temperatures in our mines, and we need to be mindful that what worked yesterday may not be the same today.

Conduct safety training sessions for all employees as necessary for changes to the operation, hazards and equipment they will work with for the next several months. As operators, it is one thing to conduct a training session and can be eye-opening when leaders are in the field validating the application of the training with the frontline miner. Contractors that work on our sites are just as important as the miners we employ and we need to ensure that the training that they receive is effective to enable them to go home safe every day.

Warmer weather operations also means more daylight hours available to "make hay." Fatigue, heat-related illness and wildlife encounters are factors that need to be considered as the frost thaws. Operators need to be regularly

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Minerals Education Coalition

National Outreach Collaboration meeting

by Rebecca Smith, MEC Curriculum Coordinator

The National Outreach Collaboration (NOC) met in-person at MINEX-CHANGE 2025, with 29 attendees enjoying presentations by guest speakers Michelle Lee, vice president of mining and market development at Westward and Haydon Mort, chief executive officer of Geologize. Lee told the conference of Westward's "No Mining, Know Mining" website (nominingknowmining.com) that presents state mining and natural resources in an interactive map of the United States, as well as lists of mining-related agencies, organizations and schools, while Mort shared the Geologize Education Resources at training.geologize.org, which offers training on practical communication about geology and mining with a goal of helping professionals effectively communicate with the

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Minutes from the MPD Executive Committee meeting at MINEXCHANGE 2025

by Nick Gow, Secretary-Treasurer, 2024-2025 MPD Executive Committee

The regular meeting of the Executive Committee of the Mineral & Metallurgical Processing Division (MPD) of the SME was called to order at 9:02 am on Feb. 23, 2025 in Denver, CO by Jaeheon Lee. Present were Jaeheon Lee, Chair; Dave Meadows, Past Chair; Tarun Bhamhani, Associate Chair; Aaron Noble, First Vice Chair; Kimberly Mills, Second Vice Chair; Nick Gow, Secretary-Treasurer; Jim Wickens, Technical Program Associate; Adam House, Membership Associate; Zach Zanetell, incoming MPD Executive Committee member; and Chee Theng, SME Liaison. Guests included Sumedh Gostu, Fangyu Liu, Michael Spicher, Rino Guajardo, Raghav Dube, Thom Seal, Jordan Rutledge, Scott Shuey, Lei Pan, Pengbo Chu, Jayson Ripke, Nickey Powell, Mohammad Rezaee, Weston Hartzell, Mike Moats, Katy McDowell, Tim Myers, Thomas Stauder, Triveni Gangadari, Chandima Subasinghe, Joelson Alves, Younes Shekarian, Mohsen Rabbani, Jim Metsa and Garland Davis.

The agenda and minutes of the previous meeting were unanimously approved as distributed, and a safety share was discussed.

Programming

The MPD technical program for the MINEXCHANGE 2025 SME Annual Conference & Expo in Denver, CO consisted of 21 sessions, including sessions for the Symposium in Honor of Professor Komar Kawatra, organized by Jayson Ripke. The Monday afternoon plenary session will feature lectures by the division's major award recipients, and a certificate presentation to the Rong Yu Wan Ph.D. Scholarship Award recipient.

World Gold 2025, organized by Nick Gow and Tom Rauch, was co-located with MINEXCHANGE 2025. The program consisted of one additional short course, hosted by Jaeheon Lee, and 37 submissions covering all aspects of gold processing.

The MPD technical program for MINEXCHANGE 2026 in Salt Lake City, UT will be led by Aaron Noble. All attendees were encouraged to attend the MPD Unit Committee Meeting in the afternoon to discuss session topics and special session ideas. Noble and Kim Mills will attend the 2026 Program Committee meeting later this week. Adam House noted that Responsible Mining and Underground Construction is scheduled for the 2026 programming, with MPD contributing one session.

Social functions and fundraisers

The MPD Scotch Nightcap will be held on Tuesday, Feb. 25. The event raised \$36,500 from three title sponsors and four supporting sponsors. The Bass Metals band will once again perform, and Secretary-Treasurer Nick Gow will serve as the host. Pre-sale tickets were capped at 450 and are sold out. More tickets will be made available at the door. Sales revenue will be determined after the conference. Whiskey

glasses, designed by Jim Wickens and sponsored by Molycop, and T-shirts featuring the Bass Metals, designed by Adam House, will be sold at the event for additional fundraising.

Based on the success of last year, an ad hoc planning committee led by Dave Meadows, MPD Past Chair, held periodic meetings with SME staff in the months leading up to the date to ensure the event ran smoothly.

The speaker for the MPD Luncheon is Mike Blois, who will speak on "The Application of Contingency in the Development of New Technologies."

The 2025-2026 MPD Calendar was distributed to all registered attendees of MINEXCHANGE 2025. Eight sponsors were secured for a total of \$17,700.

Awards

The committee recognized this year's award recipients: Antoine M. Gaudin Award — Zhenghe Xu; Robert H. Richards Award — Jaisen Kohmuench; Milton E. Wadsworth Award — Michael L. Free; Arthur F. Taggart Awards — Naci Duru and Carl C. Nesbitt; MPD Outstanding Young Engineer Award — Jordan Rutledge; Mill Gentleman of Distinction Award — Jaeheon Lee; Frank F. Aplan Award (shared with Coal & Energy Division of SME) — Jack Groppo; James Douglas Gold Medal Award (shared with TMS) — Kathleen A. Altman; and Fred C. Bond Award (inaugural) — Kaveh Asgari.

This year, the MPD Outstanding Young Engineer award was renamed in recognition of Raj Rajamani, honoring the significant contributions he had made in engineering education. The Fred C. Bond Commemorative Award is a new MPD award this year, managed by the Communion Unit Committee.

Following last year's MINEXCHANGE, the MPD Program Committee also selected and recognized the best presentations from each of the unit committees. The Best Presentation Awards were given by the Flotation Unit Committee to Brian Cook for "A Study on the Process Development of Fluorspar Flotation from the Zeerus Fluorspar Deposit," by the Communion Unit Committee to Alex Doll for "Secrets of the Bond Ball Mill Grindability Test," by the Plant Design Unit Committee to Eldwin Huls for "Tech QB2 Project Design," by the Physical Separations Unit Committee

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Fine Grind serves as a forum for the presentation and discussion of facts, ideas and opinions pertaining to the interests and technology of the Mineral & Metallurgical Processing Division. Accordingly, all material published herein is signed and reflects the individual view of the authors. It is not an official position of SME or the division. Comments by readers will be referred to that division for response. The division chair in 2025 is Tarun Bhamhani.

Meet the 2025 Mining & Exploration Division Chair Jenessa Haarala

The 2025 Chair of the Mining & Exploration (M&E) Division is Jenessa Haarala. Haarala has 20 years of technical and leadership experience in underground mining and has been an SME member since her university days. Haarala currently runs her own underground engineering consulting company and resides in Livingston, MT with her husband Pete, another highly active SME member.

Despite growing up in the mining town of Elko, NV as a child of two geologists, Jenessa never actually considered a career in mining until her first summer job at Barrick Goldstrike through their summer student program for employees' kids. "Mining just wasn't really discussed as a career path at school, plus I never thought I was all that good at math until I had an amazing calculus professor at the University of Nevada, Reno (UNR)," she said.

After enjoying her summer job in the surface maintenance department, she decided to declare mining engineering as a major. During her years at UNR, Haarala was highly involved in the SME Student Chapter, the Society of Women Engineers and the Intercollegiate Mining Competition. She spent her summers in Elko working in various departments at Barrick, and finally at an internship at Jerritt Canyon, where she developed her love of underground mining.

After earning her B.S. in mining engineering, Haarala returned to Jerritt Canyon as a full-time engineer for Queenstake Resources. There she worked at three different underground mines and experienced her first layoff in the mining industry. She briefly worked with a small, but incredible group at Barrick's Storm Mine until she and Pete had the opportunity to work at an underground gold mine in New Zealand. After two great years in New Zealand, Jenessa returned to Elko as an engineer for Newmont. She spent nearly a decade at Newmont, then switched things up by working for the mining contractor Cementation at the Pumpkin Hollow Mine and its corpo-

rate headquarters.

After the COVID pandemic, Haarala took some time off, then started Haarala Mining, where she continues to provide underground mine design and scheduling services. Once her husband also obtained a fully remote position, they realized they had a rare chance within the mining industry to live wherever they wanted. She is now delighted to have the opportunity to continue working in mining and help maintain the Montana cattle ranch that her great-grandparents homesteaded.

In the early years of her career, Haarala found it difficult to stay involved in SME. While at Newmont, she learned that volunteering in the technical program as a speaker and chair was an excellent way to earn a trip to the national SME conference. Her involvement at the national level continued to grow over her years of participating in the technical program. She was also proud to help revive the Northeastern Nevada SME section in Elko. As Chair of the M&E Division, Haarala plans to continue efforts to get more geologists involved in SME, advance plans for the trade school scholarship program, and update guidelines for some of the M&E Division awards. ■



Jenessa L. Haarala

Rock in the Box serves as a forum for the presentation and discussion of facts, ideas and opinions pertaining to the interests and technology of the Mining & Exploration Division. Accordingly, all material published herein is signed and reflects the individual view of the authors. It is not an official position of SME or the division. Comments by readers will be referred to that division for response. The division chair in 2025 is Jenessa L. Haarala.

Safety Share

(Continued from page 45)

engaged with the frontline workforce to monitor fatigue levels. Overtime can be great, but the cost to the frontline miner can be catastrophic. As the temperatures start to in-

crease, let's make sure that we monitor our miners for heat-related illnesses and service air conditioning equipment for summer rather than winter. Start talking with miners about hazards associated with increased wildlife encounters, not only at work, but also traveling to and from the mine.

Re-opening and transitioning mining operations involve significant challenges but are essential for maintaining productivity and economic benefits. By understanding the importance and potential hazards associated with these transitions, we can better prepare and implement safety measures to protect the well-being of all miners. Remember, a proactive approach to safety ensures a smooth and successful mining season. Stay safe and stay vigilant. ■

Safety Share serves as a forum for the presentation and discussion of facts, ideas and opinions pertaining to the interests and technology of the Health & Safety Division. Accordingly, all material published herein is signed and reflects the individual view of the authors. It is not an official position of SME or the division. Comments by readers will be referred to that division for response. The division chair in 2025 is Kimberly Walster.

SME Foundation Silent Auction raises money for education programs

The SME Foundation (SMEF) hosted the 2025 SMEF Silent Auction in conjunction with the SMEF Gala Dinner at MINEXCHANGE 2025 in Denver, CO. Thank you to McCarl's Technical Services for being the auction sponsor and thank you to everyone who bid. More than \$31,000 was raised this year to help fund important SMEF programs.

Thank you to the following individuals and businesses that donated items for the auction:

Adventure Mining Company
 Alvin J. Erickson, Jr.
 Andy and Julie Cole
 Anne Williamson
 Arapahoe Basin Colorado
 Barr Engineering Co.
 Bob and Pam Washnock
 Brand Safway
 Bronca
 Brooks and Nelson
 Cami Prenn
 Canary Systems, Inc.
 Cat Joyner — John T. Boyd Co.
 Scott Joyner — Montana Casting Co
 Charlie Zimmerman
 In Memory of Clancy Wendt
 Compass Minerals - Alex Hesketh
 Core Natural Resources
 Crumbl Cookies
 In Memory of Dr. Roshan B. Bhappu
 Dale Elifrits
 David Hammond
 Denver Museum of Nature & Science
 Denver Zoo
 Dorothy Snowden
 Doug Silver
 Epiroc
 Eric Shereda

Estate of Jack Goth
 First Majestic Silver Corp.
 Fogo de Chão Churrascaria Restaurant
 Freeport McMoRan
 GL Specialties — Linda Schafer
 Garland Davis
 Gold Canyon Golf Resort & Spa
 gorjana
 Great Wolf Lodge
 Greenbrier Hotel Corp & Affiliates
 Greg Beckstrom
 Hugh & Nadia Miller
 In-N-Out Burger
 J.H. Fletcher
 Jack Thompson
 Jay Nopola
 Jill Nelson
 Jim Metsa
 Jim Wickens
 Kat Tew and Family
 Katie Kosloski
 Kendra Scott Jewelry
 Kroenke Sports and Entertainment
 Kurt Kost
 Larry Evans
 Laurence James
 Lodge Casino
 Mark Savit

Mary Korpi
 Melissa Harmon
 Michael Deal
 Mike Myers
 Minnesota Section — Kurt Doran
 National Mining Hall of Fame
 and Museum
 Newmont Corporation
 Olive Garden
 Peter and Jenessa Haarala
 Rio Tinto Kennecott
 Robert Mayville
 Scott Lawson
 Shape Space
 Steve Gardner and Karen Wilson
 Steve Holmes
 The Cheesecake Factory
 The Doe Run Company
 The Escape Game
 Tom O'Neil
 Tom Rauch
 Top Golf Centennial
 Total Wines & More
 Weir Minerals
 Wendi Cooksey
 Will and Pam Wilkinson
 Wines for Humanity

MEC iron mining poster updated

by Rebecca Smith, MEC Curriculum Coordinator

The Minerals Education Coalition (MEC) Iron Mining and Processing for Electrical Uses poster has been updated and reprinted. The update includes newly added information about making green steel through the direct reduced iron (DRI) process.

The updated posters are available on the MEC Store at <https://mineralseducationcoalition.org/store/>. ■



Colorado teachers get a glimpse into MINEXCHANGE at MEC K-12 mining and minerals workshop

by Rebecca Smith, MEC Curriculum Coordinator

On Feb. 25, 28 Colorado educators had a chance to talk with enthusiastic mining professionals and receive diverse educational resources for teaching about the importance of mining and minerals.

The agenda for the day was tailored to meet teachers' needs and implemented teacher feedback from last year's workshop held in conjunction with MINEXCHANGE in Phoenix, AZ. This year's Mining Education Coalition (MEC) workshop was planned in collaboration with outreach staff from the University of Arizona School of Mining and Mineral Resources, led by Chris Earnest, with help from Mario Munoz, Dan Moreno and Gaurv Singh. The Colorado Mining Association Education Foundation's Ryan Miles, Sandi Sullivan and Maura Sullivan provided additional planning and implementation support. Pam Wilkinson of the MEC Curriculum Committee and Katie Kosloski of the MEC Committee pitched in to help at the workshop as well.

Following a compelling introduction by Kurt Doran, MEC Committee Chair, the workshop featured a presentation by MEC Committee Past Chair Wendi Cooksey of FLS, showing why mining is so critical to the transition to green energy. The teachers then had an active session trying out four hands-on activities for use in their classrooms, ranging from making toothpaste with minerals to electrowinning copper. Jeremy Diehlmann of Victaulic, a member of the SME Young Leaders Committee, provided a dynamic overview of careers in the mining industry and fielded numerous questions from the teachers. The teachers then toured six booths in the exhibit hall to talk with exhibitors from the Colorado School of Mines, Colorado Division of Reclamation, Barr Engineering, Hexagon, FLS and SRK Consulting Services.

The day ended with a free-choice period, where teachers could choose to attend technical sessions, view student posters or have more time in the exhibit hall. Lisa Rudstrom, MEC Committee Vice Chair, provided a wrap-up of the full day of education. The teachers received hard copies of SME and MEC resources focused on careers in the mining industry, a selection of MEC posters and booklets, and a USB drive with digital copies of all the hands-on activities at the workshop and more.

The teachers appreciated the hands-on activities and opportunities to speak to professionals. One teacher noted, "It took me from knowing almost nothing about mining and minerals to having a much stronger foundation of the field and career paths it has to offer."

Another teacher said, "It was definitely nice to hear from people to see how they related their schooling to their careers. Will definitely be recommending the mining field to my students as a career option."

Thank you to C. Dale and Kathleen B. Elifrits for so graciously providing sponsorship of the teacher workshop. ■



The Minerals Education Coalition hosted Colorado educators during the MINEXCHANGE 2025 SME Annual Conference & Expo in Denver, CO.

Michael Deal recognized as SME Foundation Trustee of the Year

by Lorie Laessig, SME Foundation Specialist

The Society for Mining, Metallurgy & Exploration Inc. and its SME Foundation (SMEF) Board of Trustees are honored to recognize Michael J. Deal as the 2024 recipient of the SME Foundation Trustee of the Year Award. Deal exemplifies the dedication and enthusiasm essential for a successful and impactful SME Foundation Trustee.

In his first full year, he successfully recruited Redpath Mining as a new Corporate Roundtable Partner, secured multiple key sponsors for the Arizona SMEF Golf Tournament and Gala Dinner, provided prospecting support for ABET, and personally donated to achieve his \$4K by 40 Challenge Award. His passion, commitment and outstanding contributions to the SMEF are clearly reflected in these remarkable achievements. We thank Deal for his service and congratulate him on this well-deserved recognition. ■

**Tom Rauch (left)
with Michael Deal**



Green News

Environmental Division hosts student poster session at MINEXCHANGE 2025

by Genevieve Sutton, Environmental Division Program Planning Chair

The Environmental Division (ED) held a student poster session at MINEXCHANGE 2025 on Tuesday, Feb. 25. Seventeen students presented posters to conference attendees, including a panel of ED judges.

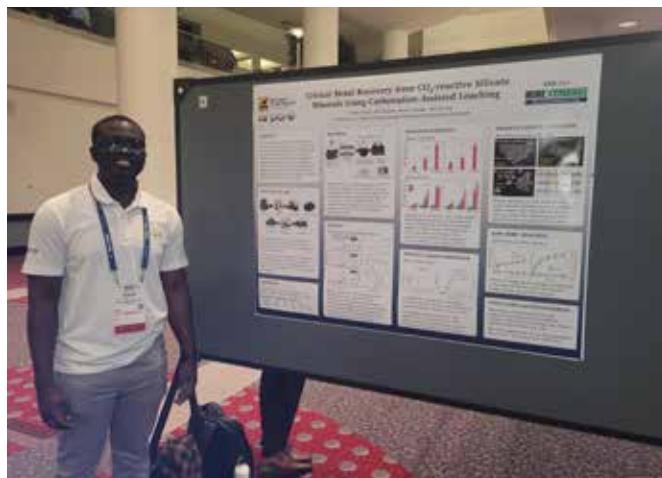
Awards were given for first, second and third places based on the quality of both the abstract and the poster presentation. The first-place poster was awarded \$2,000, second \$1,000 and third \$500. In addition, all poster presenters were welcomed at the ED Luncheon following the poster session.

The 2025 ED Student Poster Session awardees were:

- First place: Linda Jaramillo Urrego of Southern Methodist University for "Plant-Based Mercury-Free Gold Recovery in Colombian Artisanal and Small-Scale Mining."
- Second place: Kobina Ofori of Michigan Tech for "Critical Metal Recovery from CO₂-reactive Silicate Minerals using Mineral Carbonation."
- Third place: Kendra Wissinger of the University of Arizona for "Glycolipid Lead Interactions and Applications for Mining Remediation Technologies."

The ED appreciates the students' efforts and the generosity of the Environmental Student Poster Session sponsors: Arcadis, ERM and Recon.

Thanks and congratulations to all student poster presenters for their excellent work. ■



Kobina Ofori, Environmental Student Poster Session second-place winner, with his poster.

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Fine Grind

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tee to Kelly Nunes for "Additives for Magnetic Separation of Iron Ore Ultrafines" and by the Chemical Processing Unit Committee to Naci Duru for "Thermochemical Model Comparison of Gold Sulfide Ore, Copper and Molybdenum Flotation Concentrate Pressure Oxidation Processes."

Scholarships

The following MPD scholarships were awarded this year for a total of \$22,500: the Richard Kliment Memorial Scholarship for Outstanding Senior to Kathleen Troy of Virginia Tech, the Outstanding Graduate Scholarship to Chandima Subasinghe of the Pennsylvania State University, the Outstanding Junior Scholarship to Khushi Barnwal of Indian Institute of Technology, the Graduate Student Scholarship to Paula Gallego of West Virginia University, the Undergraduate Student Scholarships to Andrea Oviatt and Ellah Olson, both of the University of Nevada, Reno, and the Rong Yu Wan Ph.D. Dissertation Scholarship Award to Mohit Gupta of Virginia Tech.

MPD committees

The MPD Nominating Committee will be held on Tuesday, March 4, after the annual conference.

The MPD Unit Committee will meet in the afternoon of Feb. 23. There are still questions arising from people who are new to the division on how to get involved, so the committee discussed sending an email in advance of the meeting to announce the purpose of the Unit Committee Meeting and to remind everyone of the time and place. It was also discussed that session chairs should be reminded that they need to immediately discuss any changes in travel plans with the unit committee chair to ensure replacements can be found immediately.

Fine Grind

The Fine Grind article schedule this year filled quickly with a number of monthly submissions, seeing continued submissions such as the Colorado and Nevada MPD meeting recaps and a review of the Metallic Student Design Competition.

The editorial responsibilities for next year will be handed over to the incoming Secretary-Treasurer, Jim Wickens, starting with the article due on March 1, 2025.

Member engagement

The MPD Volunteer Interest Online Form was used this year to coordinate focused communication with the leads of the interest areas and new volunteers. Most submissions tend to come after MINEXCHANGE and the MPD Coffee Break held in December.

The MPD Coffee Break was held virtually by members of the Executive Committee to discuss how to get involved in the division and its benefits. A "best mug" competition was held. Elizabeth Toledo, a student at Universidad Nacional Mayor de San Marcos (UNMSM), was the winner with a homemade SME mug. She received a Starbucks gift card.

Student engagement

The MPD Student Poster Contest was led by Michael Spicher and will feature 37 accepted posters, by three undergraduate and 34 graduate students. The committee reminded everyone to attend the poster session on Wednesday morning and to encourage the students. Adam House, Jordan Rutledge and Hanna Spicher are serving as judges. The committee is using a new structure this year, narrowing the initial submissions to a top tier who will be asked to present in deeper depth during Wednesday morning's session. Winners will be announced during the MPD Luncheon that afternoon, and all student participants are provided with a complimentary luncheon ticket.

Aaron Noble discussed plans for an MPD Student Video/Elevator Pitch Contest intended to build a year-long cycle of student engagement to be held in the late summer or early fall as an opportunity to present research work or internship experience. Sumedh Gostu and Fangyu Liu will help to lead the endeavor. The group discussed advertising the contest in a Fine Grind article early in the year prior to internships starting. The Nevada MPD has committed to providing seed money to kick off the contest with sponsors to be considered in the future.

The Metallic Student Design Competition finals consisted of six teams: one from Canada, two from U.S. schools and three from South America. The team presentations occurred on Sunday morning, and the top three teams will be announced later this evening. Diana Rodriguez of Newmont, Isabel Penalosa of Rio Tinto, Wendi Cooksey from FLS and Miguel Pugmire of Rio Tinto served as the industry judges.

Financial review

Secretary-Treasurer Nick Gow reviewed the division finances, which will also be discussed at the Business Meeting after the MPD Luncheon on Wednesday. Division finances are strong, and all accounts are in good standing due to sponsorship and fundraising efforts over the past years.

Other conferences

Updates were provided on other MPD-affiliated conferences, including Extraction 2025/Copper 2025 (Kimberly Mills overall chair, Nick Gow and Adam House SME co-chairs). A total of 463 submissions were received for oral presentations, covering the Copper, Ni/Co and cross-cutting symposia. The committee has received 376 manuscripts, which are currently being reviewed.

New business

Thom Seal announced that the Heap Leach 2025 conference will take place this year in Reno, NV Oct. 19-21. Abstracts are currently being accepted.

A special session on waste reprocessing held jointly by the MPD and Mining & Exploration divisions is being planned for MINEXCHANGE 2027.

Adjournment

The meeting was adjourned at 10:22 am by Jaeheon Lee. ■

Kenneth John Reid

An appreciation by Greg Beckstrom and Harvey Thorleifson

The global mining industry lost a good friend on Feb. 5, 2025, when Kenneth (Ken) John Reid passed away with his family by his side after a brief illness. Reid was 90 years old.

Many people within SME knew Reid as the soft-spoken and well-dressed gentleman who was steadfast in his advocacy for the mining sector. Indeed, if you met him at a local or national SME event in the last 10 years, or even when he was a guest speaker at a Rotary Club, church or other civic organization, chances are pretty good that he talked with you about a passion project that he developed with help from his grandchildren called: "Is Mining Important?"

If you haven't viewed the video, you can find it on YouTube (do a search for "Is Mining Important?") or follow this link: https://www.youtube.com/watch?v=JXoQQB0_3SM. I expect that if Ken wrote this note, he would recommend that you view and share this video as well.

Education and professional career

Dr. Reid had a long and distinguished career in academia, industry, research and consulting and he worked in Australia, Africa, Canada and the United States. He served on several scientific and professional engineering societies in the UK, Australia, Africa and the United States.

Reid was educated in the United Kingdom at the University of Birmingham (B.S. in chemical engineering) and at Cambridge University (Ph.D., also in chemical engineering). He then did postdoctoral research at the University of California, Berkeley. Upon completion of his advanced studies and his postdoctoral research, Reid worked as a research scientist at the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Melbourne, Australia from 1963 to 1969; was an associate professor of mineral engineering at McGill University in Montreal, Canada from 1969 to 1971; and then worked for private industry as a senior process engineer with Nchanga Consolidated Copper Mines in Zambia, Africa from 1972 to 1977.

Reid then joined the University of Minnesota in Minneapolis, MN as a professor of mineral engineering and was named director of Minnesota's Mineral Resource Research Center (MMRC) in 1977. He led the MMRC until its closure in 1991 and continued teaching, writing and doing research at the University of Minnesota until he retired in 2000.

Reid's technical specialty was in process engineering, and he authored, co-authored and contributed to more than 160 peer-reviewed papers, technical reports and presentations on comminution, inorganic chemistry, mine tailings, mineral beneficiation, mineral processing, mine production, critical minerals and mineral economics.

Reid's most significant work was in high-temperature plasma technology, especially as it relates to metal ox-

ide reduction in iron and steelmaking. He started this work in the early 1980s and continued during his life with his latest work using hydrogen to replace carbon-based materials for heat and metal reduction.

After he retired from the University of Minnesota, Reid continued writing and worked as an independent mining and metallurgical engineering consultant.

Most recently, he was working on the engineering feasibility of a potential Kaloin Mine in Minnesota and doing some research on the critical minerals market in the United States.

SME and scientific society activities

Many of us in SME who knew and worked with Ken after he retired from the University of Minnesota met him after he joined the SME Southern Minnesota Subsection Board of Directors in 2008, when the local subsection of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME)/SME was reconstituted after several years of hiatus.

Reid concentrated his efforts on the subsection's sponsor drives and fundraising efforts. He was a fearless industry advocate who tactfully approached employees of mining companies, consulting firms and equipment suppliers to explain the benefits of supporting the education of undergraduate students who were focusing on STEM education. With the Southern Minnesota Subsection he also helped organize technical programs and related industry outreach activities and helped found the SME Student Chapter at the University of Minnesota.

Reid joined the AIME in 1978 and served on several committees, including as chair of the Mineral & Metallurgical Processing Division (MPD) Operating Control Committee in 1982 and chair of the Pyrometallurgy Committee in 1992.

He received the SME President's Citation Award in 2014 and the SME Foundation Minerals Education Coalition Leadership Award in 2015.

On a more personal note, those of us who got to know Ken well learned that his humanity was shaped by his strong faith, and his respect for his profession was shaped by his deep understanding of the importance of mining and community service to a civil society.

Reid is survived by his wife Gwenda; his children Paul (Janet), Bonnie (Mike) and Trudie (Mark); his grandchildren Robert (Victoria), Jonathan, Sydney, Megan, Rachel, Caroline and Reid; and his great-grandchild Lily. ■



Kenneth John Reid

Theodore (Ted) H. Eyde

An appreciation of our 1991 SME President

Theodore (Ted) Henrik Eyde, a cherished husband, father and grandfather, passed away on Nov. 15, 2024, at the age of 92. Born on Jan. 12, 1932, in Spokane, WA, Eyde was the beloved son of the late Henrik and Viola Eyde.

Eyde graduated from Montana College of Mineral Science and Technology with a master's degree in geological engineering (1957), a field to which he dedicated more than six decades of his life. He started his career with Union Carbide Corp. working on tungsten and uranium exploration in Nevada, battery-grade manganese deposits in Mexico and the first natural zeolite exploration program in the United States, identifying 185 different deposits in southwestern Canada, the western United States and northern Mexico. Eyde's zeolite discovery resulted in the commercialization of the Bowie Chabazite deposit, which is one of the world's largest zeolite deposits. Chabazite from Bowie was used to clean up radioactive contamination at Three Mile Island, Fukushima, Japan and Sojourn, Italy.

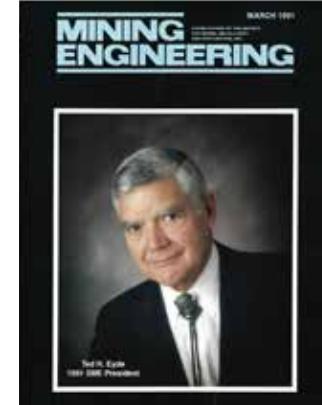
Eyde continued his career at Geotechnica SA in Spain exploring for Rio Tinto type massive sulfide copper and kaolin deposits. He returned to the United States with the Superior Oil Co., looking for copper deposits and finding three in the Texas Canyon area. The I-10 deposit is now being developed as an in situ leach operation. Eyde worked as an independent consultant for a number of years. He formed GSA Resources Inc. in 1981 with his son, Dan. GSA Resources assembled a major land position at the Bowie Chabazite deposit for Cheto Partners LLC, acquired and developed the Lyles Hectorite deposit for the RT Vanderbilt Co. and developed the Burro Creek Saponite deposit, which now is one of the largest lithium deposits in the United States. In 1999, he went on to start Gadsden Sonora Holdings with his wife, Maxine, as a geological consultant, which specialized in industrial minerals deposits with royalty interest in specialty clay deposits. He retired at the age of 86 and commented frequently on how he "hated retirement." He was one of a rare breed of geologists, a mine finder.

Eyde was an active advocate of the minerals industry and affiliated with numerous professional organizations. He worked his way up from a local section chairman

at the Society for Mining, Metallurgy & Exploration (SME) to become the 1991 SME President. Other positions include: Tucson Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers: chairman (1974); Southwestern Minerals Exploration Association: president (1975); Arizona Council of Engineering and Scientific Associations: president (1975); American Institute of Professional Geologists: president, Arizona Section (1987); and Arizona Geological Society and New Mexico Geological Society: member. He was an expert in the field of specialty industrial minerals, with more than 70 publications. He was awarded the Ben F. Dickerson Award by SME in 1998 and named a Distinguished Fellow in 1988. Eyde was also an avid member of the Toastmasters Association, beginning in 1963 in Madrid, Spain, and continuing for the next 53 years.

In 1954, Ted married the love of his life, Maxine Helen Cooper. Together, they built a life of love, laughter and adventure. Their marriage, spanning over 70 years, was a testament to their unwavering devotion to one another. Ted and Maxine were blessed with four children: Daniel Eyde (Kathy), Michele Rigter (Piet), Alicia Phillips (Vern Hause) and Dene Ross (Dan Holland), who were the pride and joy of his life. He was a devoted father, always encouraging his children to pursue their passions and dreams. He was the proud grandfather to 10 grandchildren, who brought immense joy to his life. He cherished every moment spent with them, sharing his stories, taking them out in the field and discussing politics. Ted was blessed with 17 great-grandchildren.

Theodore Henrik Eyde will be remembered for his integrity, warmth and profound impact on his family and the mining community. ■



Theodore (Ted) H. Eyde

National Outreach Collaboration

(Continued from page 45)

public about the industry. The attendees received many interesting ideas on how to speak to the public without inadvertently raising the audience's resistance to discussing the importance of mining. Mort also gave attendees a code to sign up for one of the trainings (a \$400 value) for free.

The NOC second-quarter meeting will be held virtually in June 2025 with a special presentation by Barb

Arnold, professor of practice at Pennsylvania State University. If you are interested in joining the quarterly discussions about mining outreach or to learn more about NOC, reach out to Akudo Nwokeukwu, MEC Outreach Coordinator, at nwokeukwu@sment.org, or Chris Ernest, School of Mining and Mineral Resources, The University of Arizona, K-12 education outreach coordinator and NOC chair, at ernest@arizona.edu. ■

Call for nominations: SME, SMEF, AIME and division awards

The Society for Mining, Metallurgy & Exploration (SME) administers and presents numerous recognition awards for outstanding individual and group achievements in the minerals industry. These awards and their recipients represent the highest levels of commitment and expertise that have come to symbolize the vitality of SME as a professional society. SME is accepting nominations for

SME

Robert M. Dreyer Award

Ivan B. Rahn Education Award

Robert E. Murray Innovation Award

John Fritz Medal

Cindy Moore Courageous Impact Award

SME Fellow Award

SME FOUNDATION

C. Dale and Kathryn B. Elifrits MEC Leadership Award

MEC Partnership Appreciation Award

MEC Organization Recognition Award

Miners Give Back Award

Syd S. Peng and Felicia F. Peng Ground Control in Mining Award

These awards recognize ...

Outstanding achievements in applied economic geology that must have been accomplished through commercial exploration or development of metalliferous and/or nonmetalliferous mineral deposits.

Distinguished contributions to the educational activities within SME relating to ABET, student affairs, continuing education, professional registration or the Council of Education (not necessarily an educator themselves).

Individuals or organizations who advance the mining industry through the implementation of technical innovation. Its primary focus is to award operations or organizations that are changing the mining industry through the inclusion or adaptation of cutting-edge technologies and innovative processes.

Individuals or organizations who have a scientific or industrial achievement in any field of pure or applied science.

The outstanding achievements and lasting impact of women in mining or the mine service industry.

This distinguished award recognizes SME members for their outstanding service to SME, the industry and the public. The candidate must have been a member of SME for 15 years or more.

These awards recognize ...

An individual SME member who has provided leadership to advance the mission of the Minerals Education Coalition (MEC) and has personally been involved in the delivery of its programs and/or activities.

A non-SME individual or organization that has exemplified support for the MEC's mission either through development and use of educational materials with K-12 teachers and students or public outreach and awareness about mining and minerals.

An SME group (division, local section, committee, etc.) effort that has demonstrated active involvement with the MEC's mission, either through development and use of educational materials with K-12 teachers and students or public outreach and awareness about mining and minerals.

Recognition of an SME section community service. The purpose of this program is to promote community service and humanitarian initiatives by SME sections in communities where the sections operate, and to facilitate networking between sections, as well as improving networking between the sections and SME headquarters.

An individual or a group who has shown insight and understanding of ground control issues by developing concepts, theories or technologies that have been adopted by the mining community or has successfully implemented a ground control design or designs or practices.

the awards listed below. Recipients of the 2025 awards will be recognized during the MINEXCHANGE 2026 SME Annual Conference & Expo. For more information, or to complete an online nomination form, visit <https://smeawards.secure-platform.com:443/a/solicitations/20/home>. Completed nominations are due by June 1, 2025. Questions may be directed to [awards@sменет.org](mailto:awards@sменet.org).

AIME/SME

Frank F. Aplan Award (MPD Division)

James Douglas Gold Medal (MPD Division)

Hal Williams Hardinge Award

Robert Earll McConnell Award

Mineral Economics Award

Mineral Industry Education Award

Percy Nicholls Award

Erskine Ramsay Medal

Charles F. Rand Memorial Gold Medal

Robert H. Richards Award (MPD Division)

William L. Saunders Gold Medal

Daniel C. Jackling Award

Environmental Stewardship Distinguished Service Award

Howard W. Eavenson Award

COAL & ENERGY DIVISION

Coal & Energy Division Distinguished Service Award

Rock Mechanics Award (shared by C&E and M&E divisions)

J.W. Woomer Young Engineer Award

ENVIRONMENTAL DIVISION

Environmental Division Distinguished Service Award

Environmental Division Benefactor Award

These awards recognize ...

Engineering or scientific contributions that further the understanding of the technology of coal or mineral engineering.

Distinguished achievement in nonferrous metallurgy, including both the beneficiation of ores and the alloying and utilization of nonferrous metals.

Outstanding achievement in the field of industrial minerals.

Beneficial service to mankind by engineers through significant contributions that tend to advance a nation's standard of living or replenish its natural resources.

Distinguished contributions in the advancement of mineral economics.

Distinguished contributions to the advancement of mineral industry education.

Notable scientific or industrial achievement in the field of solid fuels.

Distinguished achievement in coal mining, including both bituminous coal and anthracite coal.

Distinguished achievement in mining administration.

Achievement, in any form, that unmistakably furthers the art of mineral beneficiation in any of its branches.

Distinguished achievement in mining other than coal. The term "mining" includes the production of metals as well as nonmetallic minerals.

Significant contributions to technical progress in mining, geology and geophysics.

Significant contributions to environmental stewardship by addition to knowledge; by the design or invention of useful equipment or procedure; or by outstanding service to governmental or private organizations devoted to any field of environmental conservation.

Distinguished contributions to the advancement of coal mining.

These awards recognize ...

Achievements in the coal mining industry and service to the Coal & Energy Division.

Distinguished contributions to the advancement of the field of rock mechanics.

Engineering professionalism of young people working in the coal industry.

These awards recognize ...

Environmental Division members who have significantly contributed to the workings of SME and the Environmental Division and have an outstanding reputation for professionalism and accomplishment.

Companies or individuals who have significantly contributed to the Silent Auction to benefit the Environmental Division Scholarship Fund.

HEALTH & SAFETY DIVISION

Individual Excellence Award

These awards recognize ...

A member of the industry who demonstrates outstanding dedication, leadership or heroism in exploration, mining and/or metallurgy occupational safety and health management.

Operational Excellence Award

A mining company engaged in exploration, mining or metallurgy with exemplary occupational health and safety management performance and practices.

Research and Educational Excellence Award

An individual or a research or educational institution exemplifying exceptional innovation and dedication toward advancement in technology or education for the protection and well-being of miners.

INDUSTRIAL MINERALS & AGGREGATES DIVISION

A. Frank Alsobrook Distinguished Service Award

These awards recognize ...

Division members who have significantly contributed to the workings of SME and the Industrial Minerals & Aggregates Division and have an outstanding reputation for professionalism and accomplishments.

Industrial Minerals & Aggregates Young Scientist Award

Scientific professionalism of young people working in the industrial minerals or aggregates industry.

MINERAL & METALLURGICAL PROCESSING DIVISION

Antoine M. Gaudin Award

These awards recognize ...

Scientific or engineering contributions that further the understanding of the technology of mineral processing.

MPD Outstanding Young Engineer Award

Significant contributions of a young individual within the mineral processing and extractive metallurgy disciplines.

Milton E. Wadsworth Award

Distinguished contributions that advance our understanding of the science and technology of nonferrous chemical metallurgy.

MINING & EXPLORATION DIVISION

Ben F. Dickerson Award

These awards recognize ...

Professionalism and contributions to the mining industry.

M&E Distinguished Service Award

Mining & Exploration Division members who have significantly contributed to the workings of SME and the Mining & Exploration Division and have an outstanding reputation for professionalism and accomplishments.

Miner of the Year Award

Mine-site leaders who are able to manage production, people, community and safety and are good stewards of the environment.

M&E Outstanding Young Professional Award

Meritorious accomplishments of a young individual working in the mining and exploration industry, including related academic and governmental careers.

Robert Peele Memorial Award

Established in 1953, this award is given for the most outstanding paper published on behalf of the Mining & Exploration Division by an SME member age 35 or younger.

Rock Mechanics Award (shared by C&E and M&E divisions)

Distinguished contributions to the advancement of the field of rock mechanics.

Harry Parker Excellence Award

Exemplary performance and industry dedication in the fields of resource modeling and geostatistics. ■

Business Profiles

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APRIL
2025



Mining engineering

OFFICIAL PUBLICATION OF SME

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Wirtgen Group Mineral Technologies



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Select extraction of minerals such as coal, limestone, gypsum, bauxite, iron ore, phosphate, oil shale, kimberlite and salt are possible with WIRTGEN Surface miners.

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Complementing the flagship 4200 SMi is the 280 SMi, 260 SXi, 220 SMi 3.8, and 220 SMi, all of which combine flexibility with supreme performance when mining soft or hard material without blasting.

This innovative technology cuts expenses for machines and personnel and saves a considerable amount of time when compared to conventional methods. At the same time, it produces even, stable surfaces and embankments, and permits the selective mining of individual rock layers, cutting of haul roads and refinement of drainage.

And that's not all: Surface mining is a low-dust, low-noise method that causes no damaging vibrations, permitting mining of useful minerals close to residential areas or roads, or on environmentally sensitive projects where blasting is not allowed.

A special cutting drums cut and crush the material and robust conveyor systems then load the material on trucks or discharge it to the side of the miner. Alternatively, the material can also be deposited as a windrow between the miner's crawler tracks.

New impact crusher MOBIREX from Kleemann

KLEEMANN supplies a large range of mobile jaw crushers, impact crushers and cone crushers, as well as screening plants for processing minerals and recycling construction materials.

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Top product quality is expected from an impact crusher – and this is what the MR 130i PRO delivers together with a very high production capacity. This is provided not only by the tried-and-tested robust crushing unit with its two impact toggles and versatile rotor ledge options, but also by the 10 yd², optional double-deck post screening unit. This enables users to produce two classified final grain sizes – with a single machine and without an additional screening plant. With its heavy rotor and powerful electric 335 hp drive together with efficient prescreening, the crushing unit ensures a very stable and high throughput. Thanks to the CFS (Continuous Feed System), continuous crusher utilization is ensured.

The efficient all-electric E-DRIVE concept stands out with its low power consumption per ton of final product and offers an external power supply. The MR 130i PRO can therefore be operated locally free of emissions. Operation is carried out conveniently via the elements of the SPECTIVE intuitive operating concept such as SPECTIVE CONNECT.

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WEIR'S DOUBLE LINE HPGR AND AIR CLASSIFICATION SYSTEM DEVELOPED FOR BROWNFIELD OPERATION



Weir is continuing to build major market share in the HPGR space with its ENDURON® technology. The ENDURON solution provides significant improvements versus traditional tumbling mill technology with energy savings of up to 40% and, in turn, a lower carbon footprint. Bjorn Dierx, Weir, Director HPGR and Process Engineering, explains: "There is an increased focus on sustainability across the mining sector driven by, among others, local communities, investors and miners themselves. At the same time, there are tighter regulatory conditions around environmental permitting, all of which contributes to a broad commitment across the industry to adhere to best practice ESG standards.

"There is also a growing recognition that cleaner production of higher quality concentrate isn't just beneficial for the environment, it also improves the miner's bottom line."

Weir is promoting the ENDURON HPGR as a key component of the transformational flowsheet designed to help confront some of these market challenges, in addition to the fact that new orebodies are increasingly located in remote, arid regions. "As a result, we're seeing a shift towards dry mineral processing and

the deployment of satellite processing plants," Dierx added.

The mining community is becoming less risk averse when it comes to more widespread adoption of technologies like HPGRs and vertical stirred mills, according to Dierx.

"Apart from HPGR adoption in highly competent rock processing, we're

also increasingly seeing interest in deploying HPGRs to process soft to moderate competent ores, particularly in high tonnage applications because of the low operating expense nature of the technology," he said. "They're also being deployed in hybrid arrangements next to SABC circuits to provide flexibility when harder ore is anticipated during life of mine." And both greenfield and brownfield mines could reap these benefits.

"Many mines that have been operational for decades are now experiencing reduced throughput and increased operating costs as they are mining harder rocks and HPGR-based circuits are one of the ways they're ensuring their operations remain viable," Dierx said. "We've had some very successful brownfield installations that have simplified the flowsheets and delivered a more efficient grinding solution.

For instance, Weir collaborated with Tuprag's Kışladağ gold mine in Türkiye to upgrade their comminution circuit, replacing five tertiary crushers, six screens and conveyor belts with an ENDURON HPGR. As a result, Tuprag was able to process 4,200 t/h and increase their gold recovery by 4%.

The ENDURON HPGRs are also set to benefit from the advances Weir has made with NEXT Intelligent Solutions, which harness AI-driven technology to optimize mineral processing and maximize efficiency.

"The NEXT platform acts as an AI-based Intelligent Assistant for HPGRs that offers automated advice and recommendations," Dierx said. "The operator can choose to receive recommendations on equipment set points, or they can empower our solution to make changes autonomously. For example, adapting to changes in ore feed characteristics."

These adjustments are made based on the process data and Weir AI models, which are built to maximize throughput, while maintaining consistent product size.

"NEXT intelligent solutions can adjust the equipment or alert the operator when there are relevant drifts from the expected operational Weir's double line HPGR and air classification system developed for a brownfield operation parameter so that corrective action can be taken," Dierx said. "It also provides alerts if there's a disturbance in the process; for instance, if there's unexpected equipment failure or unanticipated process behavior."

Alongside this, Weir continues to develop innovative flowsheets, with process engineers working with miners to test and develop solutions tailored to their specific challenges and operating conditions. Dierx added: "We're also deploying existing technologies in new ways. For instance, when the mineralogy allows it, we're using an air classifier like an 'ore sorter'. Since multiple material streams can be generated, this can be combined with pre-concentration – like magnetic separation or coarse particle flotation – and gangue rejection in a single classification system. Or, alternatively, it can create a stream of sellable by-product alongside the main targeted minerals without additional pre-concentration." With these solutions having generated a lot of attention from the mining community, Dierx believes it won't be long before they are being deployed in the field.



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The company operates five manufacturing plants with capabilities that include large valve manufacturing, in-house rubber compounding, machining, welding, fabrication, assembly, painting and testing. DeZURIK also has distribution repair service centers strategically located throughout North America. DeZURIK's certification to the ISO 9001 Quality Management Program ensures the highest standards of excellence.



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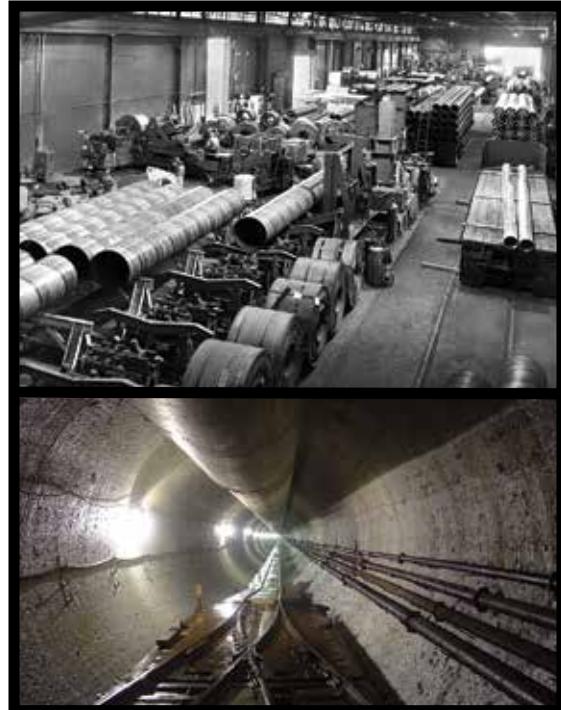


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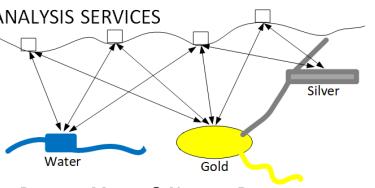
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Need for innovation crosses many boundaries



William Gleason
Editor

The MINEXCHANGE SME 2025 Annual Conference & Expo in Denver, CO and the 2025 Prospectors & Developers Association of Canada (PDAC) conference in Toronto, Ontario, Canada were two mining events separated by one week, 1,500 miles and one international border.

They are the largest annual mining gatherings in North America, each with its own unique format, audience and programming. However, this year, there were some commonalities in the presentations as well as the conversations among attendees at both events.

Proposed tariffs on goods from Canada from the Trump administration and countermeasures from Canadian officials, including comments from recently elected Ontario Premier Doug Ford, made from the exhibit floor of PDAC dominated much of the informal chatter in Denver and Toronto. The head-spinning pace of activity from Washington, DC had made it difficult to keep track of things in real time, and much has changed since early March until the time this issue went to press.

Away from the social events and chatter during coffee breaks, MINEXCHANGE and PDAC shared a common focus on another topic important to the mining industry that is evolving nearly as quickly as the news cycle — artificial intelligence.

As you might have seen in Denver or read on page 25 of this issue, the MINEXCHANGE conference featured a number of AI-focused talks, including a keynote address from Terry Jones, who referenced Ernest Hemingway's novel *The Sun Also Rises* and how it illustrates how change often happens gradually, then suddenly, much like the rise of AI, which Jones said is now at a tipping point.

Jones said mining companies should look beyond their industry and "connect the dots" from other sectors where AI has already driven substantial transformation.

During the technology and innovation keynote talk at PDAC, Flavia Tata Nardini, a rocket scientist, founder of Fleet Space Technologies and former propulsion test engineer at the European Space Agency, shared a similar vision. Fleet Space Technologies is working to launch a constellation of small satellites to enable high-value, real-time applications in industries such as mining, exploration and defense. Nardini challenged the mining industry to look beyond its own boundaries to innovate.

Nardini spoke about how Formula One racing

witnessed dramatic improvements in technology and performance when aerospace engineers became involved with the sport, and the transportation sector experienced a massive transition when computer engineers developed rideshare technology. Nardini argued that the mining industry is on the cusp of generational change fueled by technologies such as AI and machine learning, and encouraged the audience to embrace diversity in all forms, including diverse disciplines.

AI and machine learning are transformative tools that the mining industry must embrace to meet the challenge of increased demand for minerals. By 2050, the Earth will be home to nearly 10 billion people, many in large cities requiring more energy and data centers.

2024 SME President Marc Herpfer wrote often about how AI will shape the future of mining and was instrumental in MINEXCHANGE programming efforts.

"I thought it was critical to have a broad-spectrum presentation on what the current state-of-the-art is regarding AI," Herpfer told me. "And more importantly, what the future has in store for all of us. I believe the next decade will see more technological change than during the last century (the Industrial Revolution, Atomic Age, Space Age, computer revolution, and so on), and that we are just now witnessing the birth of the next age in the history of the 'epoch of mankind' on Earth. The key question is how this will all unfold, and how we will be changed and impacted by this evolution of AI as it grows from infancy to maturation?"

MINEXCHANGE and PDAC attempted to address the issues around AI and its current and future role but the discussion is far from over.

In Toronto, Tom Hunt, vice president of technology at KoBold Metals, said the need for technology in the mining industry is immediate.

"We are not on track for the energy transition," he said during a panel discussion. "We need to discover hundreds of new resources and bring them into production over the next several years, and that's simply not happening."

AI is rapidly evolving and with it technologies that will help the industry discover new resources and exploit them in a more sustainable and productive manner, but it will require commitment, innovation, investment and a willingness to think outside the box to connect the dots. "There has to be a way to access more investment quickly," Ted McGurk, head of investment banking at TD Securities said at PDAC. "If we want to achieve any of our goals on electrification and AI, we need more minerals and metals." ■



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